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SHIELD-BEARING CRUSTACEA (Recent and Fossil).

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(*With a Coloured Plate.*)

To discover the structure and investigate the anatomy of organic beings is the life-task of every true naturalist. And not only must he study the living forms of to-day, but also those which existed in the bygone ages of geologic time. For palæontology not only makes us acquainted with forms which have now entirely disappeared, but also with others which belong to still existing groups; all of which, however, fill up, and, as it were, fit into, vacant places in the series, and are needed, before we can arrive at a complete conspectus of any one class.

Among the diverse types of living forms, few, if any, exceed the *Crustacea* in interest; for they claim an antiquity so remote, and are marked by characters so varied, and yet so typical, that they are readily distinguished from all other classes, both in a fossil as well as in a recent state.*

The *Crustacea* belong to the sub-kingdom Articulata, the first class of which includes the Insects; the second the Arachnides (spiders, scorpions, etc.); the third the *Crustacea* (crabs, lobsters, etc.); the fourth, Worms; and lastly, the Internal Worms (*Entozoa*).

Great as may at first sight appear to be the difference between the perfect insect, endowed with powers of aërial locomotion, and the worm, yet it will be remembered that in

* Even the anomalous Cirripedia, the "barnacles" and "acorn-shells," show in their adult condition, on close examination, evidence of crab-character that can only be observed in this class, whilst in their larval stages they pass through similar metamorphoses to those of the higher orders.

the *larval* state the worm-like caterpillar or grub precedes the *imago*.

In the *Crustacea* almost as great a diversity exists between the highest and lowest orders as between the worm and the butterfly; but the *larval stages* of the higher forms are found closely to simulate the *adult state* of some of the lower, and seem to suggest that the latter are only the arrested stages of the former—with powers of reproduction added.

In the *Mammalia* (the highest form of *Vertebrata*) the bony framework is internal, being clothed with muscles, to which it gives firmness, and furnishes points of attachment and *fulcra*.

This is a living framework, moreover, and is kept in repair and supplied with blood-vessels which nourish it; for it has to last the lifetime of the individual.

In the *Crustacea* (which may serve as an example of the *Invertebrata*), on the contrary, the framework is external, the dermal cuticle being hardened by the deposition of calcareous matter and chitine, and within this, as in a coat of mail, the soft organs are placed, and to it the muscles of the animal are attached.

This is not, however, a permanent, but a deciduous skeleton, being cast off and reproduced as often as the growth of the creature necessitates its increased size.

These two forms, the Mammalian and Crustacean, are types of the endo and exo-skeleton (the internal and external).

In the endo-skeleton the nervous centre is placed upon the dorsal surface, and the nutritive system on the ventral; but in the exo-skeleton the reverse is the case, the viscera being placed along the back, and the nervous ganglia down the ventral surface.

Again, in the *Vertebrata* the principal development of sentient power is concentrated to form the brain, which is the capital of the whole nervous system: in the *Annulosa*, however, each separate ring or segment of the body has its own ganglion or nerve-mass, and each ganglion, in the simpler forms, seems equal to every other, and there is no specialization of any. But this simplicity of structure gives way to more complex forms as we ascend in the animal scale.

In insects the body is said to be composed of thirteen rings—head, one; thorax, three; abdomen, nine; but entomologists know that the head in insects is in reality made up of at least four segments blended together; for it is a fundamental rule in the *Annulosa*, that every body-ring bears one pair of appendages, and *only one* pair. Therefore, if we find an insect's head, bearing eyes, antennæ, maxillæ, and mandibles, we shall be quite safe in concluding that it is made up of several segments soldered together.

The type-number of segments in *Crustacea* is reckoned to be twenty-one—head, seven; thorax, seven; abdomen, seven. But here the same rule holds good; namely, that wherever more than one pair of appendages is found to a segment, that is not a simple, but a compound ring.

The combination of several segments to form one division—as the head, for instance—results in the production of a more highly-organized form, by the union of the separate nerve-masses, or ganglia—which in the lower forms remain separated—and thus a superior mass is formed, bearing some relation to the brain in the vertebrates.

Thus, in the crab, we find the body composed of a cephalo-thorax (produced by the soldering together of the first fourteen rings), and an almost rudimentary tail or abdomen.

In this division, as might be expected, we meet with those most highly-organized forms, the land-crabs, and semi-aquatic, and freshwater species, all possessing a high degree of development as compared with other members of the groups to which they belong.

Although the coalescence of the nervous centres is a point of so much importance, yet we must not allow it to supersede more general considerations of structure and habits, when treating of the Invertebrata.

For example, we find in the classification of the *Crustacea*, that the *Maia* and its allies, the triangular crabs, are placed before *Gonoplax*, *Grapsus*, and *Carcinus*—genera which display in their habits a high degree of activity and intelligence. But any one acquainted with the dull, lethargic habits of the triangular crabs (many of which, as *Hyas* and *Maia*, for instance, remain so long sedentary, that their carapaces and limbs become coated with living growths of nullipore, coral-lines, and sea-weeds) cannot for a moment doubt that the lively shore crab (*Carcinus mœnas*) ranks far before them in reality, however they may be placed in books.

If you refer to the plate you will find a series of Crustacea figured, not all belonging to the same order, but having a strong resemblance to each other in respect to the general form of their shelly covering, in allusion to which I have spoken of them here as Shield-bearing Crustacea.

They include the *Phyllopoda*, the *Trilobita*, the *Pœcilopoda*, and the *Eurypterida*.

The Phyllopods are represented in our engraving by the fossil genus *Dithyrocaris* (Fig. 9), and the recent freshwater *Apus* in its larval and adult stages (Fig. 10 *a*—*d*).

The Trilobites, by the curious Bohemian species of *Harpes ungula*, from the Upper Silurian formation (Fig. 8).

The Pœcilopods, by the two recent species of King-crabs

(Figs. 1 and 2), and by four fossil forms which carry us back in time, first, to the period of the deposition of the Lithographic Limestone, and the era of the *Archæopteryx*,* and Pterodactyles,† with long tails (Fig. 3); and then, still further back, to the great Carboniferous epoch, when the Coal-measures were accumulated (Figs. 4, 5, 6).

Lastly, the Eurypterids, which are here represented by a newly described genus ‡ (*Hemiaspis*, Fig. 7) from the Lower Ludlow Rock of Leintwardine, Shropshire, and have been illustrated on a former occasion in this work by the genus *Slimonia*§ from Lanarkshire.

In a chart of Fossil Crustacea,‖ recently engraved by Mr. J. W. Lowry (and to which we are indebted for Figs. 3—9 of our plate), we are for the first time introduced to a general view of this ancient class of Articulate animals.

By a reference to this chart it will be seen that the oldest order in time is that of Trilobites, which are characterized by the trilobed form of the trunk-segments (as well seen in *Harpes*, Fig. 8), the possession of sessile compound eyes—in most—and the entire absence of limbs of any kind. With nearly all species is found an articulated *labrum*, or lip-plate, attached by its anterior margin to the under-side of the front border of the head.

The rest of the animal must have been clothed in thin membrane only, as up to the present time no trace of limbs or other organs has rewarded the diligent search of Barrande, Salter, Angelin, and a host of others who have essayed to find them.

The next oldest group will be found to include the bivalved and shield-bearing forms, the *Ostracoda* and *Phyllopoda*; the former represented by the little *Cypris*, so abundant in all our freshwater ponds, and commonly to be seen in every aquarium; the latter by the recent *Apus* (Fig. 10) and the fossil *Dithyrocaris* (Fig. 9).

Beneath the shield-shaped covering can be seen an articulated *labrum* attached, as in the Trilobites, to the under-side of the frontal portion of the carapace. Against the sides of this labrum the jaws, armed with serrated teeth, are attached, by means of which the food is triturated. Then follows the lower lip, as it is called, and next a pair of branched and finely articulated swimming feet, followed by a series of about thirty

* See the INTELLECTUAL OBSERVER for December, 1862, vol. ii. p. 313, and plate.

† See the INTELLECTUAL OBSERVER for January, 1863, vol. ii. p. 443.

‡ See *Quart. Journ. Geol. Soc.*, Nov. 1865, vol. xxi. p. 490, plate 14, fig. 7.

§ See the INTELLECTUAL OBSERVER for Nov. 1863, vol. iv. p. 229, plate and woodcuts.

‖ A new chart of Fossil Crustacea (accompanied by a descriptive Catalogue), arranged and drawn by J. W. Salter, F.G.S., and Henry Woodward, F.G.S., F.Z.S. Engraved by J. W. Lowry, published by J. Tennant, London, Sept. 1865.

pairs of leaf-like appendages (gill-feet) which serve the office of branchiæ, and by their constant vibratory motion enable the animal to move freely through the water. When the shield is removed, the body is seen to be composed of a head bearing the eyes and thirty-three segments, terminated by a telson (or tail-plate), bearing two long many-jointed appendages. The first thirteen segments are quite soft and worm-like on their upper surface, being protected beneath the broad head-shield, the rest are ornamented with six or eight little spines along the posterior margin of each joint. All but the last six bear gills upon their under surface. The eleventh pair of feet are modified so as to form egg-pockets (ovaries), for the preservation of the eggs until the young are hatched.

We find traces of the appendages in *Ceratiocaris*, and in both *Ceratiocaris* and *Dithyrocaris* the jaws * are preserved in a fossil state.

There are several points in the structure of Trilobites which indicate a close relationship to the Phyllopods.

We find in both the articulated labrum, and although in the former (Trilobites) we do not find foot-jaws, it does not certainly follow that they had none, although the negative evidence has hitherto seemed to favour that view.

In both a greater number of segments is attained than is usual in the Crustacean type. Thus in *Conocephalus* there are sixteen (reckoning one each for the head-shield and pygidium); in *Paradoxides* twenty to twenty-two; in *Arethusina* twenty-two; and in *Harpes* (Fig. 8) twenty-eight; and if we look upon the head-shield and tail-plate as composed of several body-rings joined together, which seems certain, we have forms presented to us in which the multiplication of segments like each other is one of its leading features, illustrating that kind of growth which Professor Owen has most aptly called vegetative repetition of parts.

The next oldest group in time is found to be the *Eurypterida*, represented in our plate by *Hemiaspis* (Fig. 7), and *Slimonia* (see Plate in Intellectual Observer, vol. iv. p. 229).

It is unnecessary here to enter upon a detailed description of *Slimonia*, that genus and its allies having already appeared with illustrations in the article before mentioned. But the genus *Hemiaspis* offers some new points of structure and affinity which are deserving of notice.†

The great interest attached to this new genus is, that it appears to offer just the link we needed to connect the *Xiphosura* (King-crabs) with the *Eurypterida*.

* See my article on Crustacean teeth in the *Geological Magazine* for Sept., No. 15, vol ii. p. 401, plate xi.

† See article in *Quart. Journ. Geol. Soc.*, Nov. 1865, vol. xxi. p. 400.

Limuli, apparently differing but little as regards the carapace from the recent species of Molucca and America (see plate, Figs. 1 and 2), occur as early as the deposition of the Solenhofen limestone in Bavaria (see plate, Fig. 3); and in the Coal-measures of England and Ireland, several species of *Bellinuri* occur (see plate, Figs. 4, 5), in which the cephalic shield is composed of the cephalo-thorax; and the segments of the abdomen, if not anchylosed in all,* are so in most.

But in *Hemiaspis limuloides* we have the cephalic, thoracic, and abdominal divisions still remaining distinct, and apparently capable of separate flexure. This important character at once separates it from *Limulus* and *Bellinurus*.

It will also be observed that *Hemiaspis* is, in general appearance, strongly severed from the other species of *Eurypterida*, as well as from the *Xiphosura* in structure. The three divisions into head, thorax, and abdomen are more strongly marked. The abdomen is reduced to very slender proportions (less than one-third the breadth of the thoracic plates), and the telson, or tail-spine, is nearly one-third the length of the entire animal.

The carapace in general outline resembles *Limulus*, but is more dilated laterally.

The glabella, or central portion of the shield, is ornamented with tubercles.

The thorax is composed of six strongly trilobed segments, the *epimera* (lateral portions) being equal in breadth to the central portion of each segment.

These segments present a striking analogy to the trunk-segments of a Trilobite.

The abdomen consists of only three segments, the second and third having small bilobed epimeral pieces.

If we regard the first six body-rings as thoracic, and the remaining three segments as abdominal, we must presume that each of these latter is a double segment, as compared with the segments of the *Eurypterida* proper. (See plate of *Slimonia*, vol. iv., p. 229.)

On the other hand, the presence of these three segments precludes our considering the head to be the cephalo-thorax, and the succeeding segments the abdomen, as in the *Xiphosura*.

The smallness of the abdomen, and its reduction from the assumed normal number of six segments to three, seems to indicate a form by which, with the help of others, we may bridge over the interval that has hitherto existed between these two groups, the *Eurypterida* and the *Xiphosura*.

* In *Bellinurus regina* (Fig. 5) the abdominal segments are considered by Mr. Baily to be moveable.

With the appendages of *Hemiaspis* we are unacquainted; but the genera *Pterygotus*, *Slimonia*, and *Eurypterus*, are so well preserved to us that we are able to restore them in the most perfect manner from actual specimens.

Their appendages offer striking analogies to the *Limuli*, but at the same time we cannot neglect to notice their strong resemblance to the scorpions among the *Arachnida*.

But these fossil genera seem to have been truly marine, and to have performed their respiration by means of branchiæ, as in the recent king-crabs; the scorpions, on the contrary, are furnished with tracheæ for the purpose of aërian respiration, as in insects, a most important distinction.

We are led to regard this order as a more generalized type of *Crustacea* indicating, in Silurian times, if not representing, the *Arachnida* of the present day.

In *Limulus* we are introduced to a more compact form of organism in which the body segments are concentrated into two parts, the cephalo-thorax and abdomen; and lowly as the king-crabs appear in comparison to the Decapods (crabs and lobsters), yet they must be looked upon as a more exalted type than the *Eurypterus*, and its fossil allies, according to the laws of cephalization, as propounded by Dr. Dana and other carcinologists.

The "King-crab," or "Moluccan crab" (*Limulus*), is one of the most persistent types of organisms we are acquainted with higher than the Mollusca. For we cannot, I think, doubt that the king-crab of our modern seas is descended from those of the Jurassic formations of Germany, although none are found in intervening rocks.

Had *Limulus* represented a higher type, it is hardly conceivable that it could have existed so long, and apparently unchanged. But it seems to belong to one of those eccentric groups that appear from time to time in the zoological series, which, branching out into a by-way of its own, is checked from further onward progress; but being possessed of tenacity of life and great powers of reproduction, holds its ground, whilst higher orders are being modified or swept away.

That the king-crabs present analogies with the Trilobites few will doubt, especially when we compare them with the Carboniferous species, such as *Limulus* (?) *trilobitoides* (Fig. 6), a remarkably trilobed form.

Mr. Salter, in his *Monograph on the Trilobites* (Palæontographical Society, 1864, page 8), writes:—"Every author who has written on Trilobites has more or less perceived their analogy with the *Limulus*, or king-crab, to which there is, indeed, a good deal of external resemblance. But this resemblance totally fails when we examine the under-side of the

animal; for all the researches hitherto made (and they are many) fail to detect the slightest trace of limbs in the Trilobites. It is impossible, seeing the state of preservation in which they occur, to suppose that in every case—in fine shale, in limestone, in arenaceous mud—all traces of these organs should have been lost, had they ever existed." Mr. Salter considers (op. cit., p. 9) "that they probably lay half-buried in the silt, as is the frequent habit of the large *Limulus*, or king-crab."

The same author notices "The curious *facial suture*" (which separates the elements composing the head, dividing the cephalon into the central part, or *glabella*, and two lateral portions (cheeks), which bear the eyes)—"a line of division only faintly indicated in the *Limulus*, and which has, perhaps, no other representative in the whole Crustacean class."

"Limulus," Mr. Salter adds, "also shows a trace of trilobation; but it is accidental, rather than characteristic, in other groups."

There is only one key left to us by which to unlock these mysterious interblendings of forms belonging to distinct orders, and even classes; it is *Embryology*.

In the young state the larvæ undergo repeated moults, presenting, in the course of their progress to the adult, a series of forms totally unlike the parent, but bearing a resemblance either to the larvæ, or to the adult condition of some other genus. This is illustrated by the figures of *Apus* in our plate, the larval stages (Fig. 10, *a*, *b*, *c*,) fitly representing some of the earliest of our fossil disc-bearing Crustacea, *Peltocaris*, etc.

I hope to say more upon the subject of the larval stages of Crustacea in a future paper. Whether we view these remarkable modifications as so many separate indications of creative design, or, as resulting from the influences of food, climate, locality, and a host of other circumstances, acting upon the race for immeasurably long periods of time, the result we see around us must be the same, namely, an endless diversity of forms in every class of the animal kingdom, adapted to suit all the varied exigencies of animated existence.

EXPLANATION OF PLATE.

Fig. 1. The King-crab, *Limulus Moluccanus*, Fabr. (dorsal surface), $\frac{1}{4}$th the natural size; abundant on the coasts of Molucca, China, and Japan.

Fig. 2. *Limulus polyphemus* (ventral aspect), about $\frac{1}{6}$th the natural size; common on the east coast of North America.*

* For a description of the organs of *Limulus*, see article "On the Seraphim and its Allies," INTELLECTUAL OBSERVER, vol. iv., p. 233.

Fig. 3. *Limulus Walchii*, Desmar., $\frac{1}{6}$th the natural size; from the Lithographic stone of Solenhofen, Bavaria.

Fig. 4. *Bellinurus* (*Limulus*) *rotundatus*, Prestw., $\frac{1}{3}$rds the natural size; Coal-measures, Coalbrook-dale, occurring in pebbles of clay-ironstone.

Fig. 5. *Bellinurus reginæ*, Baily; Coal-measures, Ireland.*

Fig. 6. *Bellinurus* (*Limulus*) *trilobitoides*, Konig.; Carboniferous Limestone, Ireland.

Fig 7. *Hemiaspis limuloides*, H. W. (the natural size); Lower Ludlow rock, Leintwardine, Shropshire.

Fig. 8. *Harpes ungula*, Sternberg (the natural size); Upper Silurian, Bohemia.

Fig. 9. *Dithyrocaris Scouleri*, McCoy; Carboniferous Limestone, Ireland.

Fig. 10. *Apus cancriformis*, Schæffer; recent; living in freshwater lakes, Bohemia.

Fig. 10, *a. b. c.* Different degrees of development of the larval *Apus* (after M. Zaddach).

Fig. 10, *d.* Adult female, natural size (dorsal aspect).

CYCLONES.

BY A. S. HERSCHEL, B.A.

The revolution of the earth about the sun, its globular figure, and its daily rotation on its axis, occasions its variety of climates, its day and night, and its regular succession of the seasons. The trade winds, anti-trade winds, and monsoons are at the same time set in motion, as well as land and sea breezes, and keep up a constant agitation in the atmosphere; by which the local moisture, temperature, and density of the atmosphere are disturbed and rendered unstable. Its strata become the scene of shifting winds, and are often dislocated by tempests of the most violent kind. The most violent of these tempests are conformable to a certain law, called—perhaps in default of a better term—"the law of storms." Readers of the Intellectual Observer who regard it as a barbarism to couple the idea of law and harmony with anything so lawless as a storm, may substitute for this expression, wherever it occurs, without selection, the "theory of cyclones."

The damage occasioned by hurricanes, like the destruction caused by earthquakes or volcanoes, is incalculably great. To

* See explanation of sheet No. 137, p. 12—14, "Geological Survey of Ireland, 1859."

discover the law, if not of their production, at least of their progress, must accordingly be regarded as one of the greatest benefits to navigation. In pursuit of this laudable object, by carefully examining the log-books of vessels overtaken in these winds, Capper, Piddington, Redfield, and Reid were first led to discover the theory of cyclones, which, brought under a simple point of view by Dové, has since acquired a scientific form, and, to navigators at least, a character of the greatest importance. Navigators who avail themselves of this knowledge enjoy superior facilities, and possess greater immunity from danger on the seas than their forefathers of the last generation could have possibly foreseen.

While the "highway of nations" was thus rendered more safe, and communication between distant countries was remarkably facilitated, a system of meteorological telegraphy on land, begun as early as the year 1856, was made to connect the towns of Brussels, Geneva, Madrid, Rome, and Turin, besides several towns in France, with Paris. In the hands of its promoter, Mr. Le Verrier, it offers facilities for extending yet further the law of storms, in a manner which, in the sequel of this article, will be explained. A similar system in the Netherlands was undertaken in the year 1860, where four towns, Mästricht, Gröningen, the Helder, and Vlissingen, now regularly transmit their daily observations of the weather, by telegraph, to Utrecht. The example thus set was followed by other countries. Towards the end of the year 1860, a more perfect system of telegrams than any yet in use, including coast-warnings in the case of storms, was introduced into England by the late Admiral Fitzroy, whose barometers, and *Barometer Manual*, were already regarded as the greatest boon at many exposed stations of the coast. The project thus originally carried out consists of daily telegrams from about twenty British and neighbouring foreign ports, forming a daily "weather report" of the British Islands. Compared with the reports of the few preceding days, a "forecast," as it is called, of the weather is produced; and in the event of the passage of a dangerous storm, its track and rate of progress are announced by telegraph to the threatened ports, where the well-known cautionary signals of the "drum and cone" are exhibited, in time to warn mariners of the consequences of its approach.

The first coast-warnings, on this principle, were sent to Shields on the 6th of February; and the first weather-forecast was published on the 1st of August, 1861. Since then, continuously up to the present time, the Central Meteorological Office in London has kept a daily watch upon the weather. The results thus collected, and compiled in a series of valuable

papers by the late Admiral Fitzroy, are contained in his excellent work, the *Weather-Book*, from which many details in this article have been unavoidably and exclusively borrowed.

The first description of a great storm in England, after that of the great Armada in 1588, pretending to scientific accuracy, was written by De Foe, the celebrated author of *Robinson Crusoe*, *The Plague of London*, etc., entitled, *The Great Storm* of November, 1703. Many accounts of this storm appear in contemporary numbers of the *Philosophical Transactions*. The wooden lighthouse erected by Winstanley on the dangerous Eddystone Rock, near the coast of Cornwall, disappeared, while undergoing some repairs, in this storm, on the 26th of November 1703, and Winstanley, and all his assistants, thirty in number, perished in the sea. That actual hurricanes occasionally visit the British Islands there is reason, from the description of this storm, to believe. It will furthermore be seen, by what follows, that very destructive storms visited England at an interval of only a few years, in 1859 and 1863.

Lord Francis Bacon, and later, Dr. Halley, attempted very early to give a scientific explanation of the trade winds. Yet it was not until the year 1735 that Hadley described, in the *Philosophical Transactions*, the real origin of the trades. The law of storms, or theory of cyclones, is of still more recent date, and the subject of the variable winds appears first to have engaged the attention of Dr. Franklin in America about the year 1740. The following occurrence is narrated by himself, in a letter addressed to Mr. Alexander Small, under the date of May 12, 1760, printed in Colonel Capper's work on *Winds and Monsoons*. "About twenty years ago," Franklin writes, "we were to have an eclipse of the moon at Philadelphia, about nine o'clock. I intended to have observed it, but was prevented by a north-east storm, which came on about seven, with thick clouds as usual, that quite obscured the whole hemisphere; yet, when the post brought us the Boston newspaper, giving us an account of the same storm in those parts, I found the beginning of the eclipse had been well observed there, though Boston is north-east of Philadelphia about 400 miles. This puzzled me; because the storm began so soon with us, as to prevent any observation; and being a north-east storm, I imagined it must have begun rather sooner further to the north-eastward than it did at Philadelphia; but I found that it did not begin with them until near eleven o'clock, so that they had a good observation of the eclipse. And upon comparing all other accounts which I received from the other colonies, of the time of beginning of the same storm, and since that of other storms of the same kind, I found the

beginning to be always later the further to the north-eastward."

In this manner Franklin was first led to observe that the north-east storms of America came from the south-west.

The same peculiarity of these north-east storms was afterwards observed by Redfield, at New York, on the 3rd of September, 1821. Houses were unroofed at New York, and the wharves of the town were flooded thirteen feet deep in water. by a furious north-east storm, blowing from the quarter where Boston again is situated at a distance of only 180 miles. Yet the inhabitants of Boston, at this very time, were witnessing a successful balloon ascent; and the wind was not felt at Boston until five hours after the houses were dismantled at New York. These, and other observations of the same kind, led Redfield to the somewhat surprising conclusion, that the movement of the wind in these storms of the American coast is like that of a wheel, or of a disc laid flat—in other words, rotatory—revolving round a centre in a direction contrary to the hands of a watch. The centre of this storm, Redfield showed, was locomotive, commencing in the West Indies on the 1st, touching at New York on the 3rd, and disappearing off the coast of Nova Scotia, in the Atlantic Ocean, on the 4th of September.

Nine rotating storms were afterwards investigated by Redfield, and a chart of their central tracks was published in the *American Journal of Science* in the year 1835. At least twenty more, traced by Reid, Redfield, Piddington, and Milne, were soon added to the list of revolving storms, which happened in the North Atlantic Ocean in the first half of the present century. A chart of their tracks is given by Piddington in his *Sailor's Horn-Book*, than which no more complete work can be consulted on the "theory of cyclones."

From this chart it appears that hurricanes of the West Indies commence between 50° and 60° west longitude from Greenwich, and between 10° and 20° north latitude, not far from Barbadoes in the Windward Islands, to which the epithet "still-vexed" applies far more truly than to "Bermuthes," the island oäsis of the North Atlantic Ocean. Round Bermudas the storms sweep in a series of parabolic tracks, of which the Island of Bermudas itself is about the focus. They accordingly rarely traverse it, but their upper branches, more or less open according to circumstances, recurve towards the east between Bermudas and the mainland of America.

Another group of West Indian hurricanes, commencing about the same spot as the last, traverses the Caribbean Sea on straight-line tracks, towards the Gulf of Mexico, which they

enter, and produce upon the Mexican coast the furious winds called "*Los Nortes*" by the Spaniards.

Finally, a third group of revolving storms, consisting, like the last, of straight-line tracks, takes its rise in the centre of the American Continent, and crossing the great American Lakes to the Gulf of St. Lawrence, spreads itself eastwards over the North Atlantic Ocean. These last are winter gales, occurring in November, December, and January, while the hurricane-season in the West Indies is from August to October.

The word Cyclone (*κύκλος, a circle*), is chosen by Piddington to represent under one term the hurricanes of the West and East Indies, the Mauritius, and of the China Sea, and whatever other curved winds of the same kind are found to occur in different parts of the world. Reid and Redfield, Capper and Horsburgh, in the West and East Indies respectively, besides Piddington at Calcutta, and Dr. Thom at the Mauritius, have each investigated the law of storms in their own particular quarters of the globe, and have been led to the same conclusions. Among these names must ever be remembered that of the late Rear-Admiral Fitzroy, who so ably investigated the "Royal Charter" Storm, that "a better example for illustrating the subject is not likely to occur soon."

In all parts of the intertropical seas, cyclones take their origin near the equator. They thence progress towards the west, more or less rapidly, inclining towards the poles as they proceed, until, arrived beyond the tropical regions, they recurve in a wide, open sweep towards the east. A particular tract in the Southern Indian Ocean, called by Piddington "the storm tract," is the origin of the Mauritius cyclones; extending between 75° and 105° east longitude from Greenwich, and from 5° to 25° south latitude. Here cyclones make their appearance at the close of summer (from February until May), and, for an unexplained reason, often remain nearly stationary for four or five successive days. In general, their course is towards the west, with a speed of three to ten miles an hour, inclining towards the south as they advance. They sometimes attain the longitude of Rodriguez, Mauritius, and Bourbon, or even pass, southwards, between Bourbon and Madagascar, before they recurve towards the east. More commonly, they recurve in their course before attaining the longitude of these islands, and proceed towards the great Southern Ocean, in the direction of the desolate rocks of St. Paul's and Amsterdam.

Cyclones in the Eastern Indies occur about the changes of the monsoons, generally in the months of May and October. They make their appearance in the Bay of Bengal from 5° to 20° north latitude, and travel towards the west with a speed of three to sixteen miles an hour; meeting the east coast of the

peninsula more often near Calcutta than Ceylon. A few of these cyclones enter the Arabian Sea, and a few occur in the Sea of Andaman.

Typhoons, as the cyclones of the China Sea are called, are chiefly confined to the northern part of that sea, where they occur from July to November. They rise near the northern extremity of the Philippine Islands, and proceed westwards to the coast of Asia, between the Island of Hainan, and the latitude of Macao or Hong Kong. Their progressive speed is from seven to twenty-four miles an hour—nearly as rapid as that of the West Indian hurricanes; which travel from ten to forty-three miles an hour—the greatest progressive speed of all the intertropical cyclones.

At the centre of every true cyclone there is a calm spot, or "storm's-eye," as it is called, eight to ten miles wide, in which the air is calm, the sky, at times, is clear, and the sun by day, or the stars by night, are visible. About this part of the storm, the greatest depression of the barometer is always observed. A sudden rise of the mercury from this condition foretells, almost for certain, a violent return of the wind from the opposite direction.

> "First rise after low
> Foretells a stronger blow."

Around the focal calm to a distance of fifty to a hundred miles from the centre, according to the magnitude of the cyclone, the tempest is terrific. An able navigator once assured me that, being involved in a cyclone, and standing not far from one of the masts of his own ship, the mast was carried overboard without a sound of the falling timber being heard, to give him the least warning of the occurrence, amidst the uproar of the storm. The height or thickness of the revolving disc of air, Redfield informs us, is not greater than one mile, above which the clouds and the wind follow their ordinary course. The diameter of the storm disc, on the other hand, varies considerably, depending in many cases upon the locality of the storm.

The hurricanes of the West Indies vary from 100 miles at their commencement, to 1000 miles in diameter where they spread themselves out over the Atlantic Ocean. The Mauritius cyclones have a width of 150 to 600 miles, in the whole of which the wind blows an excessively severe gale. Those in the Bay of Bengal are 300 to 350 miles in diameter, contracting, however, occasionally to 150 miles, or even dividing themselves into two or more smaller cyclones, pursuing different paths.

The cyclones of the Arabian Sea, and the typhoons of the China Sea, are the smallest of the intertropical hurricanes, being from 60 to 240 miles across, but they are by no means

less terrible than the rest. The typhoon which happened at Hong Kong in July of the present year is one among many instances of their severity.

A few examples of the force of the wind in cyclones will serve as illustrations to the general theory of the mode of action and origin of these revolving storms.

Three hurricanes followed each other in succession over the islands of the West Indies in a single month, the month of October, in the year 1780. The first of these, on the 3rd of October, destroyed the town of Savanna La Mar, in Jamaica, by an inundation of the sea; the second, and by far the greatest of the three, on the night of the 10th-11th, swept over the Island of Barbadoes; the third disabled the Spanish fleet under Solano, in the Gulf of Mexico, on the 20th of the same month and year. The greatest of the three, known as the "Great Hurricane," passed over Barbadoes on the night of the 10th-11th of October, with a violence universally compared to that of an earthquake-shock. The strongest buildings on the island were rent to their foundations; and even the arsenals were destroyed. The spray of the sea, raised twenty-five feet above its ordinary level, was driven by the wind with so much force, as to lift a twelve-pounder gun with its carriage, more than a hundred yards from their places on the bastions. In the midst of this confusion, 3000 persons lost their lives.

On the 10th of August, 1831, another great hurricane visited Barbadoes, in which the sea at St. Vincent rose twelve feet above its ordinary level. At the north point of Barbadoes, the sea continually broke over the cliff, a height of more than seventy feet; and a salt rain fell upon the whole island, by which the waters were rendered unpalatable, and fishes in the ponds were killed. This is also related to have occurred at Mauritius, in the hurricane of February and March, 1818; and again, in a typhoon at Manilla, on the 23rd of October, 1831, the "paddy-fields" of standing rice were turned white by the salt water, which the wind conveyed to them in showers. This effect of the transporting power of the wind was noticed by Robert Stephenson in the construction of the Barra light-house. The water was turned brackish by a storm on the 16th of April, 1838, at a height of 600 feet above the level of the sea. Instances of a rain of salt-water are recorded in the *Philosophical Transactions* in the accounts of the "Great Storm" of the 26th of November, 1703.

The curious circumstance that more rain is collected at the surface of the ground than at a height of only a few feet above it, is perhaps explicable on this principle; for the spray of falling rain is carried upwards by the wind, and becoming attached to the falling drops, increases their size, and is

received in the funnel of the rain-guage, which therefore collects both spray and rain. It is observed, apparently in support of this explanation, that drops of water which fall down the shafts of deep mines gradually increase in size as they descend, until they reach the bottom of the shaft. This is probably owing to spray from other broken drops attaching itself to the drops as they descend.

To return, however, from this digression, suggested by the power of the wind upon the sea, a few instances of great inundations in a cyclone may be noticed here, as illustrating still further the force of the wind. The low-lying plains of Bengal, defended by dykes like those of Holland from sudden incursions of the sea, are frequently exposed to the attacks of the storm-waves of cyclones. Calamities on this coast are frequent, chiefly from the destruction or insufficiency of the dykes. Burrisal, at the mouth of the Ganges, was thus overwhelmed in the month of June, 1822; Balasore, at the mouth of the Hooghly, in October, 1831; and, again, Balasore and Hidgelee were completely destroyed, on the 21st of May, 1833, by a storm-wave which rose twelve feet above the ordinary level of the tide. Calcutta, on the 5th of October, 1864, suffered in its turn. The centre of a cyclone passed that day directly up the Hooghly, and caused an inundation, as well as ravages upon its banks, more fearful than any previously recorded in the history of this kind of storm.

The storm-wave, raised by the force of the wind upon a lee-shore, is in the open ocean impelled in all directions from the centre of a cyclone, and is felt at a distance of even 1000 miles as a swell upon the sea. A surf breaks upon the reefs, and a swell rises one or two feet at the Bermudas, at the passage of every West Indian hurricane near its coast. This disturbed appearance of the sea is accordingly a useful indication of the neighbourhood of a revolving storm, either approaching, or receding, or traversing the ocean, at a distance.

It is important to notice that a depression of the barometer invariably accompanies the passage of the centre of a cyclone. Sir William Reid notices an instance of a typhoon, which traversed Macao on the 5th of August, 1835; in which the barometer fell a full inch and a half at the passage of the centre; while at Canton, not quite sixty miles north from the track of the storm's centre, the oscillation of the mercury was little more than three-tenths of an inch. A number of similar cases are brought forward by Piddington, who distinguishes two classes of cyclones. In one of these, or storms of gentle depression, the mercury descends one or two tenths of an inch an hour, until the centre is near, when it remains almost

stationary, and about an equal time after the passage of the centre it gradually ascends. In the other, or storms of great depression, a further rapid fall of three to seven tenths of an inch an hour takes place in the mercury when the centre is near, or within three hours; and the mercury sometimes reaches its lowest point a little before the passage of the centre. It also immediately rises again as rapidly as it fell. The lowest depression of the mercury in a barometer yet experienced in a cyclone took place on board the "Duke of York," in the storm already noticed, at Hidgelee, on the 21st of May, 1833, when the mercury disappeared in the tube, behind the graduated scale of the instrument, at twenty-six and a half inches, having fallen two and a half inches in the preceding three hours, and remained invisible for half an hour. The oil in the sympiesometer at the same time retired completely, when the mercury in the barometer disappeared, and rose again a little before its reappearance.

Another point on which there is nothing approaching to a doubt in all the numerous investigations that have been made, is the general law of rotation of cyclones. This, in the northern hemisphere, is against the hands of a watch; and a seaman steering down the wind in the northern hemisphere has the centre on his left. In the southern hemisphere the case is reversed; the direction of rotation is the same as that of the hands of a watch; and a seaman steering down the wind has the centre of the storm on his right hand. In both cases the shift of the wind is in the same direction as the shift of the centre of the storm. By attending to these simple rules, ships not only avoid the danger of falling into the centre of a storm, but take advantage of its most favourable semicircles to continue their voyages with a prosperous wind, or even to accompany a storm upon its track.

The general law of rotation of cyclones may also be stated briefly thus:—In both hemispheres it is against the apparent motion of the sun; or, in both hemispheres it is the same as the real direction of the earth's daily rotation. The uniformity of this simple law, Dové has shown, is the result of a law equally uniform and simple—namely, the daily revolution of the earth upon its axis. For the purpose of illustration, a well-chosen example will serve, better than many diagrams, to make this clear. Suppose, for example, that an extensive depression of the barometer, arising from any cause, should take place exactly at the north or south poles of the earth. Were then the earth at rest, currents of air would stream inwards in straight lines from all sides to supply the void. But as the earth rotates about its axis once in twenty-four hours, and with it its atmospheric covering, the air;

this also revolves about the poles. Air, therefore, drawn inwards from the circumference towards the poles (where there is no motion of rotation) must, on arriving there, produce a whirl, or vortex, revolving in the same direction as the earth. Every particle of air, in its approach towards the centre of the whirl, is, moreover, obliged to obey a certain dynamical law, called the law of "conservation of areas," which requires that equal areas in equal times should be described about the centre. In this manner its rotation is enormously increased near the centre of the whirl, and a true cyclone would be produced, revolving in the same direction as the earth, or in that direction which is actually observed.

Each pole is the most central point of the hemisphere to which it belongs. The instance taken as an example is, therefore, a leading, and at the same time a typical, case of what would occur generally at any point of the earth's surface situated between the poles. A considerable depression of the barometer over any region of the earth's surface, arising from any cause, is accordingly sufficient to produce a true cyclone, or eddy of the wind, revolving in the same direction as the earth, or in the direction indicated by the "law of storms," and blowing with the greatest swiftness near the centre of the whirl.

At the equator, where both hemispheres unite, the tendency of the wind to rotate is in two opposite directions; that counteract each other; and, as far as observations at present extend, cyclones exactly on the equator are not known.

Two instances, both of them in the southern hemisphere, have occurred to verify in that hemisphere the correctness of the "law of storms." The first of these crucial instances, as they may be called, and perhaps the most striking, is the case of the "Charles Heddle," which sailed from Mauritius on the 19th of February, 1845, and proceeding northwards, on the 23rd encountered a cyclone. The ship scudded, or, in nautical language, was "put before the wind." From hour to hour, for five successive days, while the vessel drove directly before the wind, the courses steered and the distances run over were regularly entered in the ship's log. In this time, the "Charles Heddle" five times circumnavigated the centre of the cyclone, performing each revolution in the same direction as the hands of a watch, and at the same time was carried, with the centre of the storm, 400 miles back again to the Mauritius, whence she started.

The second instance, not less interesting than the last—if its very recent occurrence is considered—is the case of the vessel, "Earl Dalhousie," bound for Mauritius, which entered a cyclone in the "storm-tract," on the evening of the 14th of May, 1863. The "Earl Dalhousie" overtook and entered the

cyclone's south-east side from north-east. The vessel scudded, and was driven before the wind three times round the centre of the cyclone, while the courses steered and the distances run over, as before, were hourly entered in the ship's log. The first turn of 126 miles was performed in twelve hours; the second, of 85 miles, in eight hours; and between the second and third turns the "Earl Dalhousie" emerged from the storm into the calm centre of the cyclone, where the sky was almost clear, and the barometer fell three-quarters of an inch. The spiral incurving of the wind in this case is indicated by the narrowing circles of the ship's track. Birds and insects, in fact, are thus driven inwards towards the centre of a cyclone. Immediately on entering into the storm, the masts and yards of the "Earl Dalhousie" were thus crowded with exhausted dragon-flies. A peculiar red colour of the sky, often remarked in cyclones, was also observed, the deep purple rays of the setting sun giving the clouds a very wild appearance while the ship approached the outskirts of the storm.

In high latitudes, revolving storms occur at Cape Horn, the Cape of Good Hope, the Gulf of St. Lawrence, and on the western coasts of Europe. The severe gale at the Cape of Good Hope on the 17th of May, and another at Monte Video in August, during the present year, were probably revolving storms, proceeding on their usual course from west towards the east. On the coast of North America, as already stated, the tracks of many storms have been assigned. These issue from the centre of the continent, on straight-line tracks, across the great American Lakes and the Gulf of St. Lawrence towards the North Atlantic Ocean. They spread themselves so far, that one near Nova Scotia, on the 16th of December, 1839, is said to have reversed the trade winds on the Bahamas a thousand miles from its centre. Another, which passed over Halifax, in Nova Scotia, early in January, 1828, was followed by tempestuous weather in England, at Plymouth, at an interval of about a week, and is even suspected to have crossed the Atlantic Ocean from America to the British Islands, a distance of more than 2000 miles.

Two companion cyclones, whose centres passed nearly over Ireland, in a south to north direction, on the 26th and 28th of November, 1838, came from another part of the Atlantic. The last of these circular storms, as traced by Mr. Milne in the *Philosophical Transactions*, included the Azores, Madeira, and a large part of western Europe in its whirl. A great part of the contrast of climates between the opposite coasts of Europe and America may be supposed to arise from the existence of such cyclones on the North Atlantic Ocean, as well as from the direction of the regular anti-trade winds. Frequent north-east

gales are thus produced in the Gulf of St. Lawrence, and south-west gales upon the coasts of Europe — occasioned, doubtless, by circular storms that range at large upon the unimpeded surface of the ocean.

Telegraphic storm-warnings to shipmasters were first despatched in the year 1842, from Chicago to Buffalo, across the great American lakes. Similar systems, as already described, have more recently been adopted in almost all countries in Europe, and seaports are thus secured from the dangerous arrival of unexpected storms.

About the close of the year 1859, a collection of meteorological facts, in and around the North Atlantic Ocean, was begun in England and America, such as never could have been accumulated at any former time. In that year, on the 25th of October, a cyclone known as the "Royal Charter Storm" sprang up at the entrance of the English Channel. The storm was of the greatest magnitude and violence, and not less remarkable for its distinctly cyclonic character.

Two ships, the "Alipore" and the "Neikar," one approaching to and the other leaving the English Channel, encountered no cyclone approaching the English Channel from south-west. On board these ships, 28·98 inches was the lowest registered pressure. Its first appearance was near the Eddystone Rock, where the channel fleet at that time was stationed. At three in the afternoon, the centre passed over the fleet, the wind blowing suddenly from opposite directions, with an intervening calm space of about half an hour, during which the barometer fell to 28·50 inches. The focal calm, having thus a diameter of about seven to ten miles, passed from Cornwall, across the centre of England, to the borders of Lincolnshire, in eighteen hours, with a progressive speed of fourteen miles an hour. At sunrise, on the morning of the 26th of October, the centre was advanced not quite so far as Nottingham, and a vast whirlwind, revolving in a direction contrary to the hands of a watch, extended over England. The "Royal Charter" was lost towards seven in the morning, with nearly all on board, on a lee shore on the northern coast of Anglesea. At the same time, the west coast of Ireland, and a large proportion of that island, were not affected at all; and the weather in France continued fine. The greatest diameter of the whirl was therefore little more than 400 miles. In the north-western half of this area, the velocity of the wind cannot have been less than 60, nor in the south-eastern half much less than 100 miles an hour, being increased by the progressive motion of the storm. The storm advanced towards the North Sea, and severely assailed the coasts of Scotland, when a calm state of the atmosphere was already

restored in the English Channel. It then crossed the North Sea, and descended upon the coasts of Norway, where its energy was almost expended on the 27th.

The "Royal Charter Storm" was quickly followed by a companion-cyclone, which extended its ravages across the British Isles on the 1st-2nd of November. On November 1st, this storm's centre crossed Ireland to the north of England, and then, on November 2nd, appeared to diminish rapidly in its strength as it overspread the North Sea, progressing towards Denmark. It appears from the long-continued observations of Mr. Stevenson near Berwick, and of Dr. Lloyd at Dublin, that this track is the most frequent course of British cyclones. They chiefly traverse the northern portions of the British Islands, from south-west towards north-east, from west towards east, or even occasionally from north-west towards south-east.

Communications received at the Paris Observatory from a great number of the chief towns and seaports of Europe, enabled Mr. Marié Davy to anticipate the arrival of a furious gale in England and France, on December 1st-2nd, 1863, as early as the 27th and 28th of November. All the north coasts of France were warned upon the 30th of November. The first to be exposed to the fury of this storm, the British Isles were warned of its approach on December 1st. Rapid communications were effected on the same day along the coasts of France. The centre of the storm was advanced as far as Liverpool on December 2nd, and Cherbourg for the first time experienced the full force of the wind. Telegraphic messages, despatched from Paris on this day, reached Toulon, Genoa, Civita Vecchia, and Palermo, in time to prevent accidents to shipping in the Mediterranean; but no answers to these messages could be returned, as the telegraphic wires were, in many places, broken by the violence of the wind, which raged in France throughout December 2nd. The admirable success of these arrangements could only afterwards be learned through the columns of the public papers. The wind was first felt in its full force at Cherbourg at ten in the morning, at Toulon, near Marseilles, at half-past three, and at Genoa at half-past seven in the evening of the same day. Strasbourg, and other places in France at a considerable distance from the central track, experienced no commotion in the atmosphere until the following day.

The advantage to science arising from the judicious collection of a wide range of meteorological facts by the use of the electric telegraph, is at least as great as the services thus immediately rendered to navigation and to trade. On the charts daily published in the "bulletins" of the Paris Observatory, the barometric lines of equal pressure cross the

Continent of Europe in definite, well-proportioned, and, so to speak, eloquent curves. Nothing, apparently, prevents that the atmosphere should be delineated and mapped down at regular intervals of time, with the same distinctness as the shoals and currents of the sea. The course of European storms is clearly traced, upon these charts, arriving from the North Atlantic Ocean upon the coasts of Ireland and Scotland, and thence passing eastward across the North Sea to the Continent of Europe, where they descend to the Mediterranean Sea, or traverse the continent to the east of Russia. All that remains to be ascertained with regard to these revolving storms is the place and mode of their formation, concerning which it must be confessed that much uncertainty prevails. Perhaps the Atlantic Telegraph Cable, when completed, by connecting Europe with the opposite lip of the great Atlantic basin, will supply us with the missing link. At present, the subject is made one of increasing interest, by Mr. Le Verrier's recently-undertaken study of the meteorology of the North Atlantic Ocean.

PLEASANT WAYS IN SCIENCE.

No. II.—Equilibrium and Repose.

In the first of these papers we considered certain facts belonging to what we designated "Curiosities of Motion." We found that all things change, and that nothing is absolutely still. Let us now consider a few phenomena belonging to conditions of equilibrium and repose. In an absolute sense, no objects can be so described, but very close approximations to these conditions may be found throughout the universe. Equilibrium means a state of equal balance, and we shall arrive at some elementary and serviceable ideas by considering a pair of scales, or, more simply, a well-balanced scale-beam, without the pans. If such a beam be placed in perfectly still air, and away from sources of disturbance, it will remain perfectly level; but if accurately made, the slightest force acting upon either end will produce an oscillation, and, if continuous, a subsidence of the end affected. A feeble current of air, a very small magnetic or electric attraction or repulsion, a gentle heating of one end, with consequent expansion changing the position of the centre of gravity—any of these things will disturb the equilibrium, and cause a state of motion to follow the state of rest.

Now, making a pair of scales may appear a very simple thing, and yet, when a near approach to perfection is required,

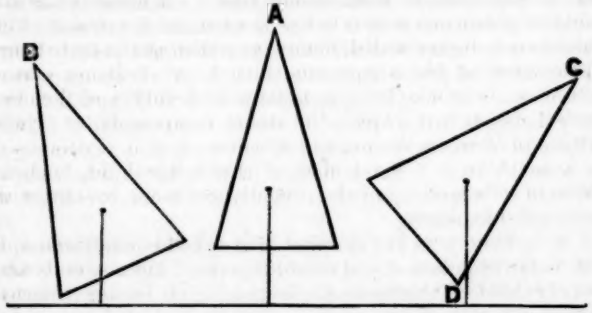
the task is found to be surrounded by a variety of difficulties, requiring considerable skill and science to overcome. To understand this, we must arrive first at a distinct comprehension of what is meant by *centre of gravity*. Terrestrial gravity, or weight, means the mutual attraction exerted between the earth and any given body, as, for example, a piece of wood. Take a strip of wood, or of card, which will do as well, say six inches long, and half an inch wide, run a needle through it near one end, and support the needle on a couple of wine-glasses, so that the card can fall between them. The long end of the card will touch the table on which the glasses stand, and, if lifted up, will immediately fall back again. Why? Because the earth attracts and is attracted by all the particles of the card, and there are more of them in the long end than in the short; that end therefore falls. If the short end is weighted, so as to attract and be attracted by the earth as much as the long end, a balance will be obtained, and neither end will fall. The quantity of weight on either side of the needle which passes through the point of suspension can be adjusted quite as well by moving the needle as by adding to the weight of the lightest end. There must be a point in every solid so situated that exactly as much weight lies on one side of it as on the other. In a regular solid, like a solid square or a solid parallelogram, we can find this point by drawing diameters across opposite corners; they will cross in the centre of the figure, which is also its centre of gravity. In a circle, the centre of the figure is likewise the centre of gravity, presuming always that the object is of equal density throughout. In irregular figures, the centre of gravity is more troublesome to find; but when found, has the same property, that if the object is suspended at that point it can remain at rest. A body acts as if all its weight were concentrated in its centre of gravity; and, consequently, whatever be the mode of its suspension, the centre of gravity will fall as low—that is, as near the centre of the earth—as it can. Now, if a body has a pin run exactly through its centre of gravity, and that pin is strong enough to bear its entire weight, it is obvious that the centre of gravity cannot fall lower than it is already placed. To do so, it would have to break or bend the pin, which we have supposed impossible. If, therefore, we run the needle exactly through the centre of gravity of our piece of card, we shall find that it can be at rest, or balanced in any position. Both arms may be horizontal or vertical, or in any intermediate position; and whatever tendency of weight operates upon one arm in one direction, must operate upon the other arm in exactly an opposite direction, and so both arms will be in equilibrium wherever they are placed.

In these experiments we suspend a body, free to move about the point of suspension, so that it may be at rest in any position; and we see that to do so, we must suspend it by a support passing through its centre of gravity. Let us now suppose we wish to communicate motion to any body, so that all its parts shall be impelled in the same direction, and with uniform velocities; how are we to proceed? Take a billiard ball for an example. If one side of the ball is struck, that side is impelled to move faster than the other; but if the ball is hit exactly in the centre, its tendency is to move straight forward in the direction of the impelling force. Thus we see that, if an object is struck, so that the line of the force acting upon it passes exactly through its centre of gravity, the whole body is impelled to move straight forward with equal velocities affecting all its parts. If struck to the right of its centre of gravity, one side is impelled to move quicker than the other, and consequently the body rotates round its centre of gravity as well as moves forwards, if it is free to do so. The centre of gravity of a body has therefore two noticeable properties—a support passing through it will supend the body, so that its balance is not disturbed by change of position, and a force passing through it impels the whole body to move equably forward in front of the impelling force.

A body is in a state of equilibrium when the action of gravitation does not tend to alter its position; but there are three distinct kinds of equilibrium — *stable*, *unstable*, and *neutral*. Stable equilibrium indicates a decided preference for a particular position of equilibrium. This is the case when a cone is allowed to stand on its base. If you lift the base up a little on one side, it falls back to its previous position; and in order to make it fall over, you must lift one side of the base so much, that a perpendicular from the cone's centre of gravity shall fall beyond the base, and then it will fall over on its side. Any body in stable equilibrium has its centre of gravity so far from the edge of its base, that if thrown slightly, or even considerably, out of position, it tends to fall back to where it was before. A centre of gravity is in its normal position when it has fallen as low—that is, as near the centre of the earth—as it can. If elevated above the lowest point it can reach, and allowed freedom for motion, it will get back to the lowest point by the shortest route. In the annexed diagram, let the three triangles represent three cones. Their centres of gravity will be exactly over the centre of the base, and one quarter of the distance from the vertex to the base above it. In A a perpendicular from the centre of gravity is considerably distant from either edge of the base. In B we see it displaced, but its shortest way of getting to the lowest point is to fall to the

right, so as to bring the cone back to the position shown in A. In C, the nearest way for the centre of gravity to reach its lowest point is by the cone falling on its side towards the right; and it will be seen that a perpendicular from the centre of gravity falls in the same direction to the right of the base and outside it. A body like A is in a stable equilibrium, because a moderate or considerable disturbance leaves it able to recover its position. If C were balanced exactly upon the point D, it would be in unstable equilibrium, because the slightest force would make it fall on either side.

Neutral equilibrium is when a body cannot alter the position of its centre of gravity by any motion it can take. It is thus equally at rest, or in equilibrium, in all its possible positions. A ball resting on a plane is in this condition, because its revolution leaves its centre of gravity at all times exactly as high above the plane as it was before.



To return to our scales: let the piece of card already spoken of represent the beam. If the needle by which it is suspended passes exactly through its centre of gravity, it is in neutral equilibrium, and the two arms balance each other in whichever way they are placed. But if the needle is moved so as to be a little above the centre of gravity, a slight motion of the beam elevating or depressing either arm is resisted by its weight, because any such motion lifts the centre of gravity above its lowest point, to which it will immediately fall back, and at which it will settle after a few oscillations. If the needle is again moved, so that it is placed considerably below the centre of gravity, the slightest force will throw the beam on either side, and it will not oscillate, but remain fixed as soon as the centre of gravity has reached its lowest point.

This sort of explanation is dry to read, but may readily be made interesting by the performance of the experiments described. In making scales, two things have specially to be

considered—firstly, the elimination of friction, so that the least possible obstacle of that kind may hinder the free motion of the beam; and, secondly, the arrangement of the point of suspension above the centre of gravity, so that the beam may be in stable equilibrium, to the extent of always desiring to return to one and the same position, but with this tendency sufficiently weak as to be counteracted by a slight force. The exact distance between the centre of gravity and the point of suspension must be determined by the use to which the scales are to be put—the greatest delicacy and freedom of motion being required for the most precious articles, and the most accurate weighing.

It seems a sudden jump from a pair of scales to a percussion cap, but yet the transition is easy. A good pair of scales are just within the conditions of stable equilibrium, and a percussion cap contains a substance—fulminate of mercury—which is just outside those conditions. Chemical forces are capable of balancing each other as mechanical forces do. The balance may be upset with difficulty, and then the body belongs to the class of stable compounds, such as all ordinary earths and stones; or it may be upsettable with facility, and then the body belongs to the class of unstable compounds, of which fulminate of mercury is one, and which we find is decomposed by a smart blow. Some bodies of this latter kind, such as chloride of nitrogen, explode violently on mere contact with most other substances.

A body may be in the state of rest called equilibrium, and yet be far from actual and absolute repose. Thus a scale beam, equally heated throughout its length, is in active internal motion; but as both arms are lengthened at the same time, and in the same proportion, the equilibrium of gravity is not disturbed. Astronomy furnishes remarkable instances of groups of balanced motions producing the equilibrium of systems, every part of which moves in harmony with the rest. Astronomy also brings before us the conception of compensated disturbances, or aberrations, an arrangement which permits certain departures from the main plan, in such a manner as to consist with the stability of the whole. If we descend from great things to small, and pass from Nature's grand clockwork in the starry orbs to man's little clockwork with his chronometers, we find analogies in the mode of operation; and that form of pendulum, in which the expansion and consequent lengthening of the pendulum-rod is counteracted by the expansion and rise of mercury in the glass vessel which constitutes the pendulum-bob, illustrates to some extent the mutually compensating irregularities by which the true relation between suns and planets is maintained.

It is by establishing the kind of equilibrium we have described that bodies are preserved as *wholes*, notwithstanding the motion of their parts, or the change of their constituent atoms. The inorganic world affords us continual instances of the first of these actions, and the organic world of the second. In the latter there is an approximate equilibrium of waste and supply. The two processes are seldom equal. When the supply predominates in a healthy individual, growth is obtained; and when the waste predominates, dissolution ensues.

The social world has its equilibriums, stable and unstable, like the physical and the chemical worlds. In societies in which rights are respected and duties performed, the stable equilibrium is attained; and if disturbance ensues, and the fabric shakes under hostile assaults, it may still regain its condition of individual activity and collective repose; while in other societies in which injustice is the predominant force, the resulting equilibrium of despotism is unstable, and when a shock comes the

"Castles topple on their warders' heads."

It has been well said that "harmonious motion is divine repose." Absolute rest, with its negations, so appalling to the European mind, constitutes the highest felicity of the Buddhist; but in a healthy human being, a higher kind of rest is achieved in the compensating movements and harmonious working of divers faculties. The muscular system relieves the nervous, the nervous excites the muscular; the affections not only stimulate the intellect, but they relieve its labours; and by a grateful alternation of different modes of action, life's varied functions are performed in due season, so that to exist is to enjoy.

ON THE SPECTRA OF PIGMENTS.

BY HENRY J. SLACK, F.G.S.,

Member of the Council of the Microscopical Society of London.

When light reaches us by reflection from a coloured object illuminated by white light, the effect upon our eye results from the rays which remain in the spectrum after the object has removed by absorption other rays which are complementary to its own colour, and which would make white light if added to that colour. In like manner, coloured transparent or translucent bodies, on which white light falls, absorb certain rays and transmit others—those which they absorb and those which they transmit being together equal to white light. If therefore we view through a spectroscope that portion of white light which is transmitted or reflected by a coloured object, the character of the spectrum will indicate the exact nature of the absorption that has occurred.

The application of the spectroscope to the microscope just made, in a new pattern, by Mr. Browning, and figured in the last number of the Intellectual Observer, is exceedingly convenient for such experiments, and I have made several, both with flowers and pigments. It is the latter only that will now be described. The most interesting pigment spectrum I have as yet seen is that of cobalt. A little patch of the water-colour paint so named is laid in flat tint on a piece of white paper, illuminated by a bull's-eye, lieberkuhn, or side reflector, and viewed through the micro-spectroscope, when two bands are seen in the green, much like those of the blood spectrum, and a third line in the red. An inch or two-thirds is a convenient power for these experiments; and it will be remarked that, in the cobalt spectrum, the bands in the green look green, and that in the red looks red, both being of darker tint. If a minute spot of blood is placed upon a piece of white paper, and a spot of cobalt immediately above or below it, both will come into the field at once, with an inch or two-thirds, and the resemblances or differences between the two spectra can be conveniently observed.

It is interesting to compare the spectrum of ultra-marine with that of cobalt. With care, a cloudiness is seen affecting the green somewhat unequally, but no distinct band in the spectrum of the former pigment.

When a little patch of vermillion is seen through the micro-spectroscope, the purple is stopped out, and the green converted into a dark greenish grey.

Emerald green affords a spectrum from which the purple is excluded, while a delicate shade overspreads the green. A dark shade is seen in the least refrangible red, and a lighter shade in the rest of the red and yellow.

Yellow ochre, purple, and blue shut out, dark shade in green nearest the blue.

Rose madder, shadow in purple and blue, band in green.

By pursuing these experiments with a variety of coloured objects, an insight will be gained into Nature's method of painting, and some curious optical facts may be ascertained. When water-colour paints are laid on white paper, if transparent, they allow a certain portion of white light to be reflected from the paper; and if opaque, it will generally be found that certain roughnesses in the paper have remained comparatively unaffected by the pigment. More white light will also be reflected at certain angles than at others. Allowance must be made for these facts; and with some colours the experiments may be conveniently varied by transmitting a bright pencil of light through the paper on which they are placed, and contrasting the effects of transmitted and reflected light.

Having tried the spectrum of cobalt as a water-colour pigment, take a piece of the blue glass with a violet tint commonly used in decoration, and said to be coloured with cobalt; this gives a fine spectrum with transmitted light. On trying a piece rather more than 1—16″ thick, a broad dark band was seen at the edge of the red and yellow, next to which was a band of dingy red, only visible under strong illumination, occupying part of the place of the yellow, then an apple green space, and then a dark green band, with a paler green space leading to the blue. Another piece of blue glass, rather thinner and with less of the violet tinge, gave a similar spectrum, with some slight though interesting differences. The dark tint between the two bands in the red and yellow was paler, and less opaque. Experiments should be tried with various tints of smalt glass, of different thicknesses.

THE FLINT TOOLS OF NORTH DEVON.

BY TOWNSHEND M. HALL, F.G.S.

(*With Two Plates.*)

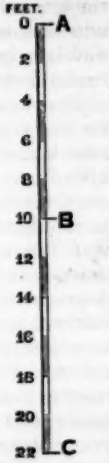
No field of investigation so completely acts as a connecting link between the geologist and antiquary as that which within the last few years has excited such an unusual amount of interest, and has been the ground of much dispute—the records of Prehistoric man as read by the light of the flint implements from the "Drift." The question stands now as it has stood for some time past. Flints of a certain shape are found in the drift, a deposit considered by geologists to be of an antiquity so vast, that no scale of time can be correctly applied to measure its age. If therefore the flints received their shape from the hands of man, then the human race must have existed at the time of the formation of the drift-beds, and must be of an antiquity equally great. Although this reasoning may be perfect in a logical point of view, still for practical purposes and for practical inquirers it may be somewhat too inductive in its character. Two important questions arise at the very first stage of the subject. First, are the flints really shaped by the hands of man, or is their peculiar form of cleavage produced by natural causes of fracture? Secondly, is the drift of the extreme antiquity geologists have assigned to it? With regard to the first, the flints which have been found can all, or nearly all, be classed according to their shape, and reduced to three or four definite patterns or standards. Natural causes of fracture will no doubt, on very rare occasions, split flints into a somewhat approximate form, but it would be stretching the bounds of the laws of probabilities to too great an extent to suppose that all, or even a fractional part of the number of shaped flints found at different times in France and elsewhere, could have received their form by natural sources of fracture. Of course some natural process, of which we are now ignorant, may at one time have been in operation; but if in the valley of the Somme, in the Dordogne, and in two or three places in England, it turned so many flints into hatchets and arrow-heads, how is it we do not find abundance of these arrow-heads and hatchet-shaped flints in Hampshire, Wiltshire, Dorsetshire, and every other county where the raw material is so plentiful, and where therefore the "natural process" would have full scope for development? Other evidence bearing on the question of art *versus* nature is to be found in a bulbous projection which may generally be noticed on the flat side of the flake. It always points out the spot where the

blow was administered to strike it off from the mass; corresponding depressions may be seen on the other facets of the flake, thus showing that it is the result, not of one chance blow, but of at least three or four successive blows, each administered in the proper place, and consequently it must have been the work of an intelligent being.*

Secondly, are the drift-beds of the immense age assigned to them by geologists? In the valley of the Somme, for example, where they are considered by the highest authorities to be of fluviatile origin, was the detritus necessary for their formation brought down by the rivers, torrents, and glaciers of old, at a uniform rate, one year after another? for if the accumulating force was irregular or intermittent in its action, then measurements and calculations of thickness in feet and inches can afford us no very satisfactory criterion of age. A lake will soon form in a valley, especially if the surrounding district is uninhabited, or peopled by a race of savages. A tree will fall across the stream, this will cause others brought down by the torrent to accumulate on the same spot, and by degrees an embankment of considerable height will arise to restrain the flow of the river, and form a lake. But after a time either the increasing pressure of the pent-up water, or the decay of some material composing the bank, will cause the barrier to burst, and not only will the accumulated matter be brought down by the flood, but for miles it will sweep away every obstruction, scoop out the river-bed, and form, when its violence is expended, a thick bed of *débris*, which will spread over the whole width of the valley, and be almost uniform in its thickness. Thus although from the general conformation of the ground it is improbable that such a lake ever existed in the immediate neighbourhood of Abbeville or Amiens, where the valley of the Somme is little less than a mile in width, still if a cataclysm of this nature took place further up, in the contracted part of the valley, it would not only account in part for the low-level drift, but also for the fact that the "tools" are found at such an unequal depth below the surface. Thus they are sometimes met with at a depth of 30 feet. One mentioned by Sir C. Lyell in his address to the British Association at Aberdeen in 1859, was found in the pit of St. Acheul, near Amiens, at a depth of 10 feet. Mr. Evans, too, in his paper to the Society of Antiquaries, read June 2, 1859, states that in the same pit he saw one *in situ*, 11 feet from the surface. Another, found by him at Hoxne in Suffolk, lay at a depth of 8 feet, and some from Long Low, Wetton, are described in the same paper as occurring "near the surface;"

* See *Archæologia*, vol. xxxix., p. 76.

"a circumstance," adds Mr. Evans, "which in no way affects the question of their antiquity."* Taking for our data the two weapons we have first named, found at St. Acheul, at a depth of 10 and 11 feet respectively, and contrasting them with two others found in the very same pit, the one at a depth of 20 feet below the surface, and the other discovered by Mr. Flower lying *in situ* at a depth of 22 feet,† let us for the sake of simplicity make use of a diagram, and put A to represent the present time, A.D. 1865, B the minimum (10 feet), and C the maximum depth (22 feet), at which weapons have been found. It will then be perfectly clear that if the drift has accumulated at a uniform rate per annum, man must have existed at Amiens during a period so long that the difference in age between B and C is considerably more than equal to the number of years which must have elapsed between B and A; and can we conceive it possible that during this long, long time any race of man, however savage, could go on generation after generation continually fashioning the same old shape of knives, arrow-heads, and hatchets out of flint without the slightest improvement, and leaving us not even a fragment of pottery to attest their progress in the arts?

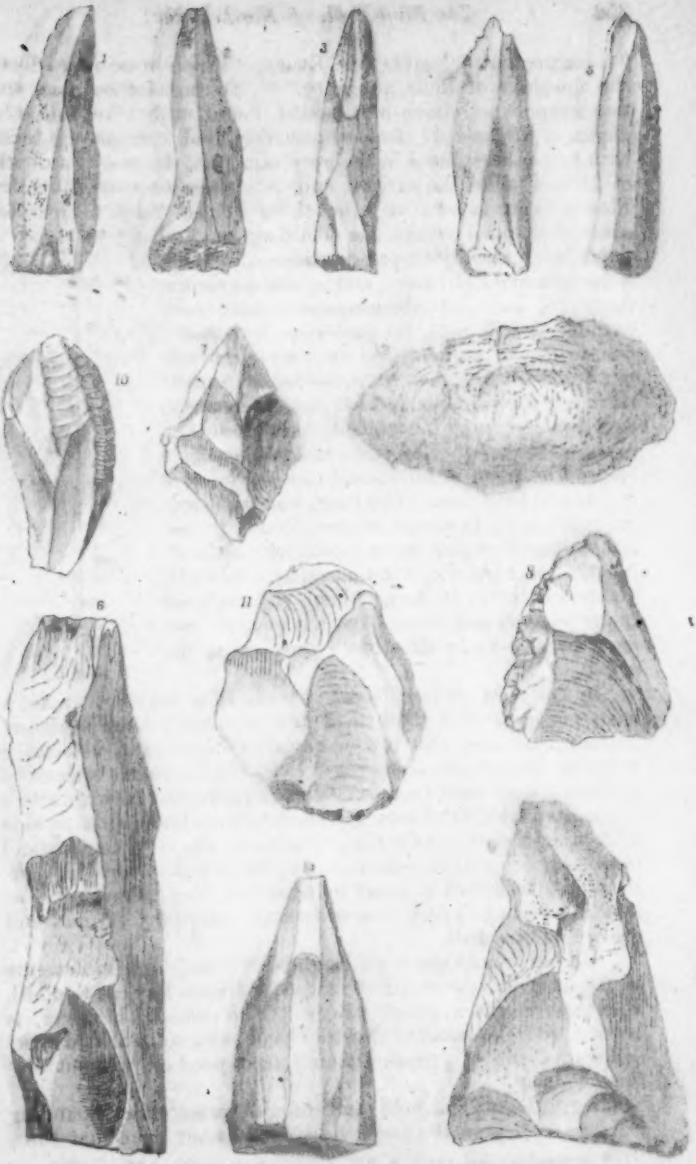


In this brief sketch of the records of Præhistoric man, I have purposely left untouched the evidence of the bones of extinct mammals, which in many places are found associated with the implements, because remains of the same species of mammals have been found in caves in juxtaposition with man's bones and articles of man's workmanship—found side by side with flint flakes, combs, pins, armlets, rings of bronze and iron, and coins of the Roman Emperors from Nero to Constantine,‡ therefore it must be admitted they cannot serve as infallible data to prove or disprove the antiquity of man and the age of the drift.

Passing from France to England we find flint implements in the drift at Hoxne in Suffolk; near Herne Bay, at Bedford, and two or three other places. This article, however, is headed with the name of North Devon, and so to that district and its records of primeval man I must proceed without any further delay.

Baggy Point, the bold and rugged promontory bounding Barnstaple Bay on the north side, and distant from that town

* *Archæologia*, vol. xxviii. p. 302. † *Antiquity of Man*, p. 103.
‡ *Geologist*, vol. iv. pp. 539—295.



T. M. Hall, F.G.S., delt.

FLINT IMPLEMENTS FROM NORTH DEVON.

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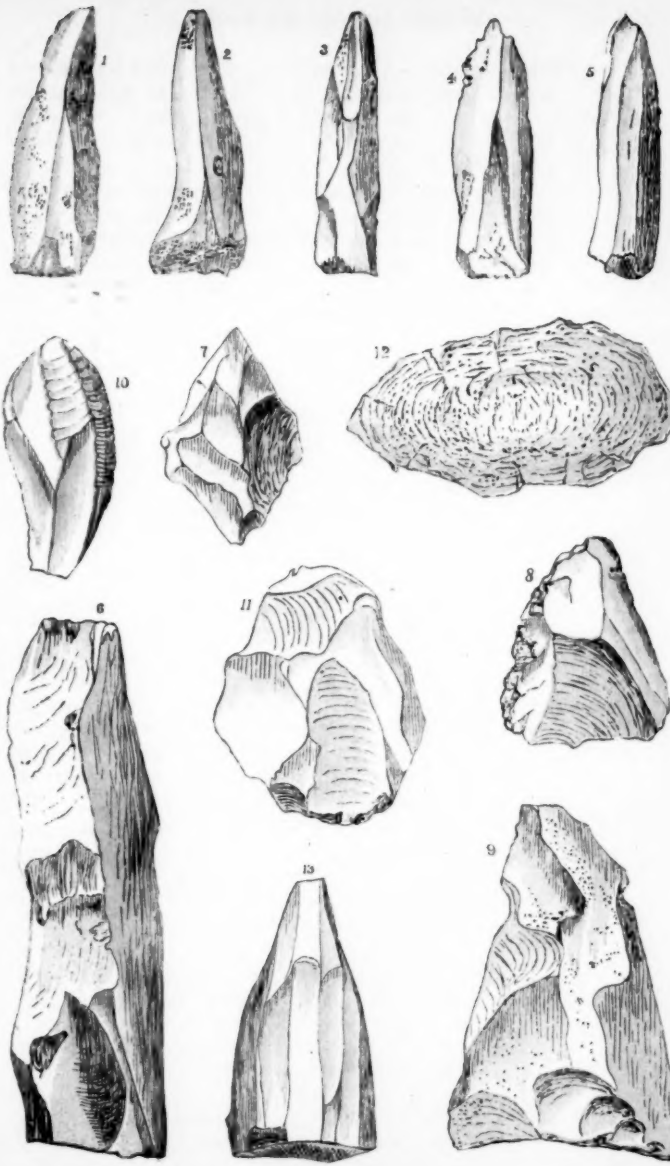

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FLINT IMPLEMENTS FROM NORTH DEVON.

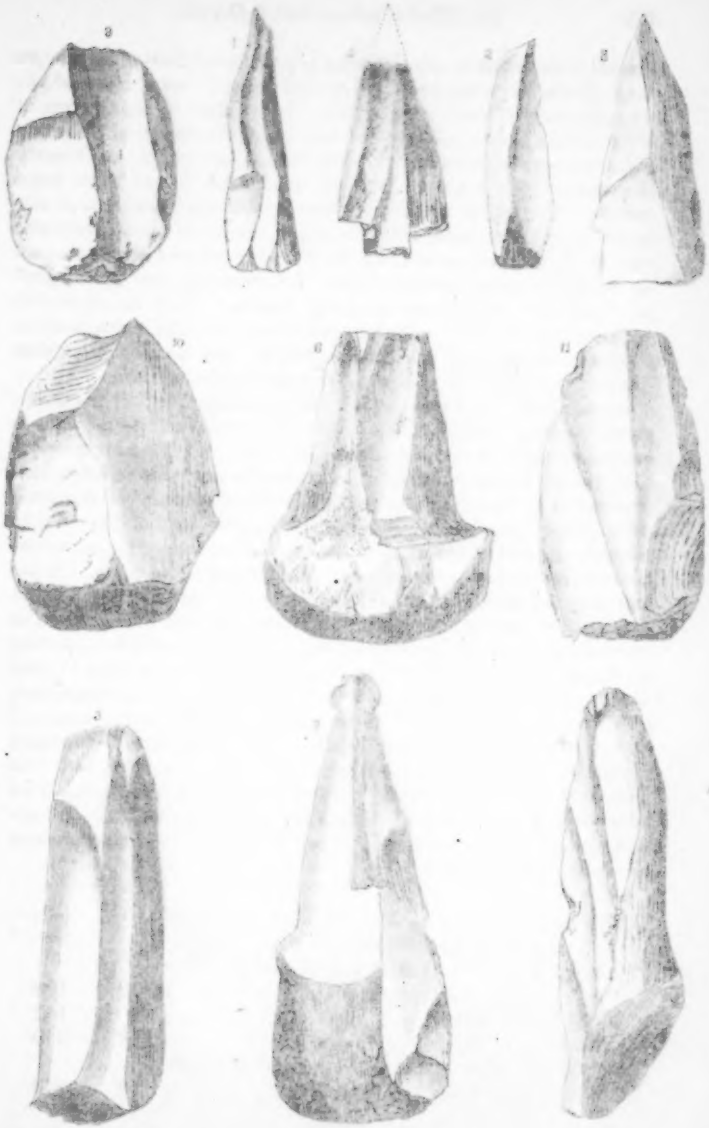
ten miles, is well known to geologists from the raised beach which extends for a considerable distance along its coast, at a height of nearly 40 feet above the present level of the sea. It has been described by Sir H. de la Beche, and has at different times formed the subject for two or three papers to the Geological Society. Drift beds 16 feet thick occur in several places, mixed up with the raised beach; but as both formations are at the same level, and of nearly the same thickness, they are never visible together to their full extent in any one section, one always takes the place of the other, either altogether or in part. In one place where the raised beach is entirely wanting, and the drift occurs at its full thickness, I have found lying immediately on top of it, rude flint implements in great numbers, associated with calcined flints, rough sun-dried pottery, and a chipped stone hatchet. The majority of the "tools" are only flakes, or futile attempts to produce three definite forms, amongst which knives and arrow-heads appear to be the favourite shapes; and although the flint employed must have come from a considerable distance, chippings of the material are associated in such profusion with the tools as to imply that there must formerly have been a manufactory of implements on the spot. They are covered with from 3 to $3\frac{1}{2}$ feet of compact and undisturbed alluvial soil, of which the six or eight inches next the drift, and enclosing by far the largest proportion of flints, is a layer of black earth, forming a great contrast to the reddish colour of the ordinary soil. One peculiarity of their geographical situation must not be left unnoticed. They are found near the mouth of a transverse valley, where there is a small flat space about 200 yards square, sheltered completely from the north by a range of hills, and more or less also from the east and west. A small stream of fresh water flows down the bottom of the ravine, all conducing to render the spot suitable in the estimation of savages for the site of an encampment. Over most of this flat area flakes (many of them carefully chipped) appear to be scattered, but in some places they occur much more abundantly than in others. Amongst the large quantity of these flints found at different times by myself in this one locality, there is a great gradation, not only in the size, but in the form of those which must be included under the name of "arrow-heads and knives." A reference to the accompanying Plates will show that many of the tools bear unmistakable signs of having been chipped into shape with the greatest care, and those of our readers who are acquainted with the unrivalled collection of M. Boucher de Perthes, at Abbeville, and the new Amiens Museum, will recognize the close affinity between the "tools" from Baggy Point and some of the

smaller implements from the valley of the Somme, although none of the large hatchets, so abundant in France, have as yet been discovered in North Devon. Some also are analogous in form to the ruder weapons found by M. Lartet and the late Mr. Christy, in the caves of the Dordogne, others are clearly the cores from which the thin knife-like flakes have been struck. The chief number, however, are chippings, and the larger fragments, although they show traces of design on the part of the maker, have been rejected as utter failures to produce anything serviceable, either for domestic use or for purposes of war. Some few are mere pieces of flint knocked off, apparently, in the very earliest stage of the manufacture, showing on one side the conchoidal fracture, and on the other the original external coating, or crust, of the nodule.

After many excavations, numbering altogether ten or eleven, since August, 1863, I lately determined to make one on a more extensive scale, in order to ascertain exactly the relative proportion which the arrow-heads and knives bear to the failures, and therefore, on the 19th of July last, took advantage of the kind offer of a gentleman staying in the neighbourhood to supply me with two or three men, so as to make a thorough examination of the spot which appeared most fruitful in tools. A pit was dug through the alluvium down to the drift. Its length was 12 feet, and the width at the narrowest end 7 feet, while at the south end it widened to 14 feet. All the earth was thrown up for me to examine, and the result of a careful search (I may say sifting) was the discovery of 366 flints, counting fragments of all sorts, shapes, and sizes, which, on my return home, I classed under the following heads. The first column of figures gives the actual number of specimens of each type, and the second the proportion that number bears to a thousand. The latter will consequently be found the most convenient for purposes of general reference, as from it the exact percentage can so readily be obtained.

Flint flakes shaped carefully by chipping, they all approximate in form to one of three types (see Plates), and are imperfect only as regards deficiency in point	72	196
Ditto, badly shaped and imperfect	60	162
*Attempts of the rudest description . . .	114	316
Cores, generally of large size, from off which flakes have been struck.	53	144

* Among the attempts and failures I have counted many which were accidentally broken by the workmen.



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Flint flakes shaped carefully by chipping, they all approximate in form to one of three types (see Plates), and are imperfect only as regards deficiency in point	73	196
Ditto, badly shaped and imperfect	60	162
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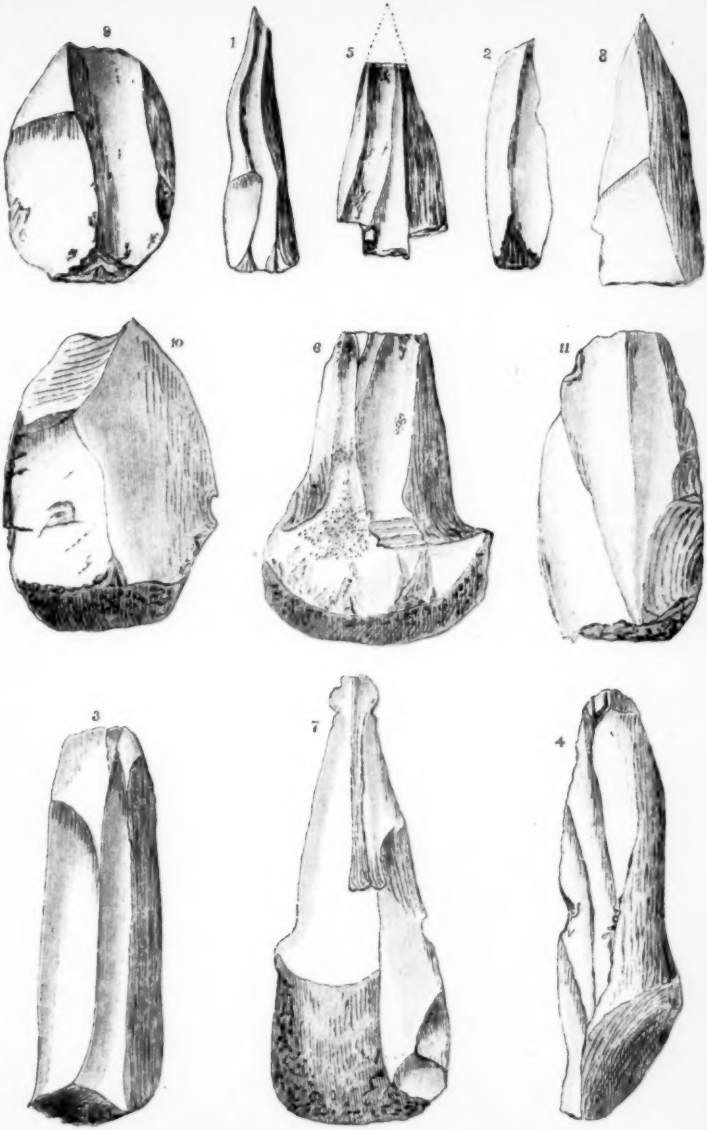

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Fragments of flint, showing conchoidal fracture on one side, and the external coating or crust of the nodule on the other . . .	34	92
Calcined cores and flakes	30	81
Whole flint nodules	3	9
Total	366	1000

Let us now analyse the facts of the case. In the first place, flint is not found naturally in that part of North Devon, as there is no chalk nearer than seventy miles, and green sand with flint occurs only in two fields at Orleigh Court, in the parish of Buckland Brewer, distant from Baggy Point thirteen miles in a direct line, of which four are across a portion of Barnstaple Bay. Supposing, then, a manufactory of weapons existed at Baggy, it is evident that the raw material necessary for the formation of the tools must have been brought either by sea or land a considerable distance for that express purpose.

Secondly, the presence of calcined flint is of great importance as a proof of human handiwork. Everybody knows that flint splits naturally with what mineralogists term a conchoidal, or shell-like fracture—in fact, the same kind of fracture that may be seen in broken bottle glass, or in obsidian; but flint, as soon as it is subjected to the action of fire, immediately loses the conchoidal, and assumes a hackly fracture, when it becomes perfectly impossible to split or chip it into any shape or form. Many out of the thirty calcined flints have flat surfaces and facets, showing a conchoidal fracture; and this circumstance, therefore, affords conclusive evidence that their shape was received by splitting and chipping, *before* they were subjected to the action of fire.*

Lastly, the evidence of the pottery and stone weapon. The former consists of three fragments, just sufficient to identify as having originally belonged to an urn, or some vessel of similar shape, which, when perfect, must have been 8¼ inches in diameter. One of the portions contains a small projection, evidently intended to serve as a handle. Bits of quartz have been worked up with the clay, so as to give it greater consistency. It is fashioned rudely by the hand, sun-baked, and totally destitute of any attempt at ornamentation.

With regard to the artificial character of the stone "hatchet," I can speak less positively. It is made of very hard sandstone, and certainly bears the appearance of rough chipping, whilst one side shows traces of the action of fire. Still, as this

* So completely is the texture of the flint altered by the calcination it has undergone, that small cracks or fissures traverse the flakes from one side to the other, and its specific gravity is reduced from 2·54 to 2·4.

"tool" is the only one of its kind found in that locality, it may possibly be only a stone selected from the neighbouring beach, with the view to turning its peculiar shape to account, for the purpose of a weapon, and therefore, with such uncertain data, I am unwilling to speak too definitely on the subject. Thus much for the evidence of art; but proofs of antiquity are not wanting, for, apart from the fact that the flints are covered with nearly four feet of undisturbed soil, in a desolate and almost uninhabited part of North Devon, there is another and surer proof in the patina, or varnish-like film which covers most of the flakes. It is produced by a very slow and long-continued chemical action, and may be regarded as a good, though not universal sign of great antiquity. Indeed, the only occasion on which it appears to fail, is when the flint partakes largely of the nature of agate or chalcedony.

Thus it will be seen, on carefully comparing the flint tools of North Devon with those of the first or Drift period, that they differ materially in two points only. They are found immediately on top of the drift, instead of in it, and they occur in juxtaposition with certain proofs of their human origin, whilst, at the same time (although on the average much smaller), they are as rude in design and manufacture as any of those from Amiens or Abbeville.

They differ, on the other hand, from those of the second, or Celtic period, by being split and chipped into form, instead of having their points and edges shaped by the more civilized process of grinding.

To which class, then, must the tools of North Devon be referred? Are they to be put amongst the implements of the first period, because they are chipped, and not ground; or are they to be ascribed to some early tribe of Celts, on account of the associated pottery? Or may they not, rather, form a connecting link in the scale of progression between the two? That there must have been such connecting links is obvious, otherwise how could the Celts have followed so closely in the steps of the men of the "Drift," making the same shaped tools, but making them look better, by a long and tedious process of grinding. With the ground and polished tools of the second period are found pottery and various articles, indicating a considerable advance in knowledge and intellect. Did man, then, make this progress at a sudden bound? Did he suddenly discard all weapons made in the old style by chipping and splitting, and use none but those which involved the expenditure of much labour on the part of the maker, and, after all, made but a poor substitute for the knife-like edge of a split flint? Or is it not more probable that this progress was the result of a gradual development of intellect; and that,

if the axiom of Bacon is true of nature—"*Nihil facit per saltum*"—it is true also of the progress of Præhistoric man? The drift and alluvium of Europe has, comparatively speaking, been but little explored; and no doubt new discoveries, or further investigations into some of those which have been made already, will throw more light on a subject interesting alike to the geologist and antiquary, the ethnologist and divine.

Plates I. and II. represent flint flakes from Baggy Point, drawn (full size) from specimens in my collection. The reader may see at a glance that they resolve themselves into three distinct forms or types, although between these forms there are numerous gradations, caused by the uncertain character of the material of which they are made.

REFERENCES TO THE PLATES.

Plate I., Figs. 1—6; and Plate II., Figs. 1—4.—Tools of the first type. Flakes or knives usually of the same width near the top, as they are at the bottom.

Plate I., Figs. 7—9; and Plate II., Figs. 5—8.—Second type. Arrow-head shaped weapons, which sharpen to a point more or less gradually from their base.

Plate I., Figs. 10—11; and Plate II., Figs. 9—11.—Third type. Oval implements with a cutting edge all round, or nearly so.

Plate I., Fig. 12.—The flat side of a calcined flake.

Plate I., Fig. 13.—Small core, from off which flakes have been struck.

NEW EXPERIMENTS WITH SOAP BUBBLES.

BY JOHN BROUGHTON, B.SC.

Our subject is not of very difficult or complex manufacture. It is very easy to take a little soap, and shake it up with some soft water in order to form a lather, to take a tobacco pipe and dip it in the solution, and then the foundation of the bubble is made. For across the bowl of the pipe the soap, dissolved by the action of a cause of whose nature we know but little, has enabled the water to form a film, which, liquid though it be, is braced with a drum-like tension. This strain, whose existence can be readily demonstrated, would, if the soap were not present in sufficient quantity, cause the film to break immediately by its own contractility. Now blow through the pipe, and the liquid membrane will be swelled out, its capacity for expansion far exceeding caoutchouc, and the thing of beauty grows rapidly to its maturity, and glows with all the magnificence of its perfections of colour and form, changing every second in the former, until the limit of its strength being reached, fragile as lovely, it vanishes into invisible spray, leaving its name as a byword for beauty without substantiality. To make evident this contractile force of the film, which is at once the cause of its existence and destruction, it is only necessary to blow a bubble with a moderately wide glass tube instead of a tobacco-pipe, and when it has attained to considerable dimensions, to present the end of the tube to the flame of a lighted candle, when the contractility of the film will expel the contained air with such force as to extinguish the candle. If, instead of expanding the bubble to its limit of strain it be dexterously jerked off its parent pipe, by virtue of the same cohesive force it instantaneously closes the rent made in its side and floats a short time, a sphere of nearly mathematical perfection; but the contact of a foreign body destroys at once the uniformity of tension on which its existence depends, producing undue strain at one particular part, and so the unmanageable beauty commits suicide at a touch. If our plaything escape the profaning touch of anything less fairy-like than itself (and I may here remark that they have a great dislike to touching one another, being brought into actual contact with difficulty), it contains within its own constitution elements of destruction. For the film of which it is made, thin though it be, is liquid, and must, therefore, obey the liquid laws; hence the solution gradually runs down to the lowest point, till the upper surface becomes so thin that it can no longer support the strain to which it is exposed, and the

bubble by bursting resolves itself into the simpler form of spray. Besides this, as will subsequently be shown, the film is of excessive tenuity, and the rapid evaporation of liquid from its comparatively enormous surface, soon reduces its thickness to the bursting point. In fact, a soap bubble depends for its being on the accurate adjustment of the equilibrium of many component forces, each of which acting alone would be its destruction, and this equilibrium, being but unstable, is destroyed by the slightest cause. But, on the other hand, if these conditions of its existence be not interfered with, a soap bubble will bear an amount of rough treatment that is surprising in a being otherwise so ephemeral.

Thus our bubble, though a charming thing while it lasts, has such a fragile nature that it can with only the greatest difficulty be employed for any long-continued observation; and for this reason many attempts have been made to discover some means of prolonging its existence. For though generally only considered as a toy, it has already been found to have its uses. Newton spent much time in endeavouring to discover the cause that produced its glorious tints, and how well he succeeded is known to most of my readers. Faraday made soap bubbles the vessels for containing the gases between the poles of the electro-magnet in his great experiments on the magnetism of gases. As a means of prolonging the existence of the bubble, Brewster* recommends the addition of some sugar to the solution, which, by somewhat diminishing the fluidity, has some effect, and makes it slightly more available for optical purposes. But the successful method is that employed by M. Plateau, the Belgian physicist, who, finding a liquid film necessary to his researches on the deportment of liquids freed from the influence of gravity, invented a solution which forms bubbles of a beauty and permanence almost incredible. The recipe for this solution in its most perfect form is as follows:—

Dissolve one part of pure oleate of soda in fifty parts of distilled water, and to every three volumes of the clear solution thus formed, mix two volumes of pure glycerine.

This mixture, used instead of soap and water, with a common tobacco-pipe, gives bubbles whose tints are truly gorgeous, and which are best observed in the following manner:—Take a piece of iron wire, about the thickness of a darning needle, and after cleaning off any rust with sand-paper, bend it in the form here given, the diameter of the ring being about $1\frac{3}{4}$ inches. This is readily managed by wrapping it round any convenient

* *Optics.* Ed. 1853, p. 119.

cylinder, such as a broom-handle, leaving the perpendicular portion about four inches long, to serve to affix it to a piece of wood as a foot, the wire ring being a support for the bubble.

To place a bubble on the ring it is only necessary to blow one whose diameter is about one and a-half times that of the ring, and then by means of the pipe allow the bubble to rest lightly on the ring at one point, after which, by continuing to blow, the whole of the circumference of the ring can be brought gently in contact with the bubble without injury to the latter. When this has been accomplished, the pipe can be withdrawn by slightly slanting the bowl of the pipe with one edge towards the bubble, and thus removing it, when the latter remains comfortably resting on the ring. The above is easier to perform than describe, since the bubble has now a comparatively robust constitution, and bears a deal of handling. If any difficulty be experienced after one or two trials, it will be found to disappear if the ring be first well wetted with the solution to remove any traces of grease.

When the bubble is thus established, there is no present fear of its bursting, for if it be made with well-prepared materials, it will possess wonderful durability. When shielded from draughts by being covered with a glass shade, it forms an ornament for a drawing-room. Their duration in a pure atmosphere varies generally from an hour and a half to four hours, but occasionally they last much longer. On one occasion a bubble of fine dimensions remained for twenty-seven hours before bursting. Several bubbles on rings placed in a bright light form quite a blaze of beauty: their colours are best seen by arranging them on a black ground, in order that they may be visible by reflected light only, by which the tints, for optical reasons, are seen in much greater brilliancy.

The extraordinary permanence of our now improved plaything depends greatly on the purity of the oleate of soda. This substance, which is merely the soda soap of a peculiar fatty acid, requires, for its preparation in a state of purity, some chemical skill, and the employment of a process which may be found in the manuals of organic chemistry. The following process, however, gives it in sufficient purity for most purposes, and is easily carried out. Take some good sweet almond oil, such as is used by clockmakers and gunsmiths, put it into a convenient vessel, such as a porcelain basin or a clean

iron saucepan, and mix it with about one-and-a-half times its bulk of a strong solution of caustic soda; then heat it to boiling for some time, keeping it well stirred. The oil will thus gradually, by the action of the alkali, be converted into a soap. The heating must be continued till all the oil has been decomposed. This may be ascertained by dissolving a few grains of the mixture in water, when, if any unconverted oil be present, it will be seen to float. If after some time the oil still separates, more soda must be added, and the boiling continued till the desired end is attained, some excess of soda being always necessary. The mixture should then receive the addition of an equal bulk of water, so as to bring it into complete solution, and the whole allowed to cool, when a quantity of white soap will separate from a clear liquid. This soap should be strained and squeezed on calico, till no more liquid can be pressed out. Then it must again be dissolved in hot water, and a little more soda added, and allowed to cool. It will now again separate, and must be pressed as before, till the cake of soap is quite hard, when it will be pure enough for making the solution.

Should the foregoing process (which is less troublesome in practice than its description appears to indicate) be found too difficult, there is yet another plan which, though not quite so successful, is far more easy. It is thus:—Shred finely 150 grains of Castile soap (which can be procured of any druggist), and shake it up in a bottle with half a pint of distilled or pure rain water until it is at length dissolved, then allow the turbid solution to settle, and filter through blotting-paper. The clear solution can then be used to mix with glycerine instead of that of the pure oleate.

I will now suppose a bubble made with our solution, and successfully placed on its ring. It will after a few minutes be glowing with gorgeous colours, which vary almost every minute from the richest violet to the most brilliant orange. Now darken the room. Then take some common spirit (brandy will do) that has previously been shaken up with some common salt, and with it moisten some cotton wool, which inflame. Now look at the bubble illuminated by the yellow light thus produced. Instead of the former lovely tinted sphere we see a yellowish thing, and on a closer inspection, we find that the parts formerly the brightest are now marked by streaks and smears of a dead black, which are shifting about continually. They are not beautiful certainly, but are curious when we remember that they mark the lines and surfaces of equal thickness where the yellow light, by reflection from the two surfaces of the film, is made to extinguish itself, and produce the darkness. If instead of a salted spirit

flame, a bull's-eye lantern with a piece of red glass be used, so as to view the bubble by red light, a similar effect will be seen. Those parts which are dark by red light are green by daylight, for then the red rays are blotted out of the composite white light, leaving the green ones.

When our bubble's life has lasted some considerable time, it commonly happens, especially if shielded from draughts by a glass shade, that a small purple spot makes its appearance at the uppermost portion, owing to the liquid draining away to the antipodal extremity. This spot when it first appears is scarcely larger than the point of a pin; but small though it be, it indicates the eventual decay of the beautiful sphere; for by very slow degrees the spot enlarges, and bright yellow points, like minute flecks of gold, appear within its circumference. During the enlargement of the purple spot, a series of Newton's rings, of every brilliant rainbow tint, forming concentric circles for about 25° round it as centre, gradually make their appearance, while, less definite in position and extent, the colours of the remainder of the bubble are constantly varying from one bright shade to another. In fact, nothing can be more beautiful or interesting than to watch the slow consumptive changes which end in the dissolution of our plaything. It is, from these wonderful optical effects alone, a source of unwearying interest. Slowly the spot increases, the velvety purple becomes very nearly black, and, in addition to the bright golden spots above-mentioned, others appear of intense blackness, which resemble minute holes. Frequently the central spot attains a diameter of three-sixteenths of an inch, with edges looking like a mosaic of gold and gems; but while we are gazing on the changes which occur almost every second, it vanishes, leaving no trace, save a film spread over the wire ring. It frequently happens that these effects of the central spot and rings are not at first obtained, but a few trials, and perhaps a slight addition either of the oleate solution, or of glycerine, will ensure success, which will well repay the expenditure of trouble. These changes, from the first appearance of the spot to the destruction of the bubble, commonly occupy about twenty minutes.

Another of the many interesting diversions which the bubbles furnish is that of filling them with a gaseous mixture, which will just neutralize the influence of their gravity. For this purpose a bladder or gasholder, provided with a stop-cock, should be filled with a mixture of about one volume of common coal-gas and eight volumes of air. By means of an attached tobacco-pipe bubbles of about three inches diameter can then be blown with this mixture; and after detaching, by touching with a wet finger the drop of liquid clinging to their under

surface, they can be detached from the pipe and started floating. If the balance be well-adjusted, which is readily accomplished by making the balloon a little smaller or larger, according as the gas employed be strong or weak, it will hang, like Mohammed's coffin, self-suspended in the air, if the latter be quite still; but being a very sensitive indicator of currents, it will generally move in some particular direction. Thus it will slowly creep along the walls of the room, mount to the ceiling, and descend by the other branch of the current that carried it up, or it will go so near the ceiling that its destruction appears inevitable. But not so; there being always a cushion of motionless air on the surface of large objects, it will float out of danger in a most surprising manner, unless some asperity of surface should attack it. If it escape the latter danger, it will remain floating and creeping about till it gradually loses some of the coal-gas by solution in its liquid sides, when, becoming heavier, it sinks and bursts.

Notwithstanding the sensitiveness of our bubble to unkind usage, it possesses in some respects a very remarkable invulnerability. It is well known that ghosts and other apparitions do not sustain the least injury either when they are shot at, chopped at with battle-axes, or pierced with sword thrusts—in fact, this peculiarity is invariably demonstrated in perfect ghost stories. This peculiarity is shared by the fairy-like subject of the present article. Pierced with needles, thrust at with knitting-pins, they remain without a wound, nor does a scar remain to testify the gash. Drops of water and small shot may be sent through them without producing any perceptible symptom of inconvenience; indeed, they may be pierced with a pen-knife (in a manner that would reduce a less eerie thing into slices), with scarcely any disturbance of its unsubstantial being. But like the silver bullet which infallibly destroys a ghost, so does a particle of grease on any of the above offensive weapons destroy our bubble, for then it requires but a single touch, and all is over—it vanishes; its liquid sides can no longer adhere, as though its stainless nature could not endure the impure contact.

This property of invulnerability suggests, however, to the unpoetical mind some curiosity as to the thickness of this strange liquid film that forms our bubble. It certainly seems at first almost impossible to effect a measurement of so intangible a magnitude, and of a substance which cannot, from its nature, be put (as in the case of gold leaf) into the balance and weighed. It is true that there is furnished by the light which produces such splendid tints on reflection from its two surfaces, an indirect means by which the distance that separates them can be ascertained, supposing the angle of vision at

which a definite colour is visible, and the refractive index of the solution be known. But this method does not readily apply to our present inquiry, and would only be fairly applicable to thicknesses producing the circles of colour produced at the upper part of the bubble, which are described above, since the same colour may be produced by various thicknesses of film.

Again, a slight examination of the bubble shows that the colours vary considerably even in spaces only a line square, especially when it is well expanded. This circumstance renders the determination of the mean thickness of the bubble by the optical method practically useless. It is, therefore, necessary to have recourse to some other indirect means of weighing and measuring. It is true we cannot put our bubble into the balance, but still there is a device by which we can make a determination so readily that any reader can make a direct experiment on the thickness of the film of any particular bubble. The method I refer to is to blow a bubble with a gas of known specific gravity, which is less than that of air, and of such a size that it will neither ascend or sink in the air, whose specific gravity is known. The size of the balloon being known, the weight that its contained gas will support is readily calculated, and this gives the weight of the balloon. This being known, the thickness of a spherical shell which such a weight of liquid would form of the diameter of the balloon is readily determined by a calculation, and this is equal to the mean thickness of the balloon. From such experiments the writer has found that bubbles have a thickness varying from $\frac{1}{15,000}$ to $\frac{1}{31,000}$ of an inch*, the latter number representing that of a thin bubble. Wonderfully thin as is their dimension, it is greatly exceeded by that of gold leaf, which

* The following illustrates the method :—

A bubble, carefully freed from drops of liquid at its lower pole, and of 3·5 in. diameter, filled with a mixture of one volume of hydrogen to sixteen volumes of air, showed no tendency to ascend or sink.

Let s = sp. gr. of hydrogen = 0·0691.

s' = sp. gr. of the bubble solution = 1·1.

g = number of grains in a cubic inch of water = 252·456.

t = thickness of film.

r = radius of balloon = 1·75 inches.

w weight of balloon.

$$\text{Then } \left(\frac{4r^3\pi}{3} \times \frac{31}{100}\right) - \left(\frac{4r^3\pi}{3} \times \frac{31}{100} \times \frac{16+s}{17}\right) = \frac{4r^3\pi}{3} \times \frac{31}{100} \times \frac{1-s}{17} = w$$

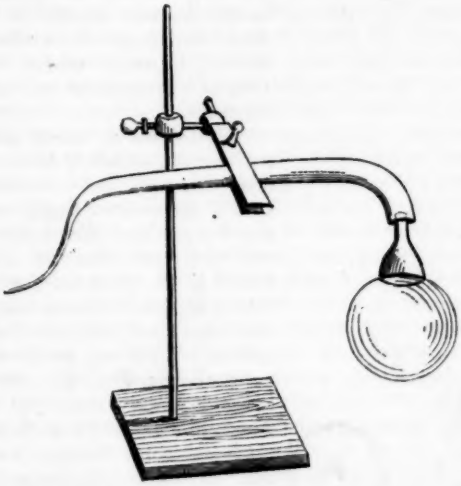
Also $4r^2\pi\, t\, g\, s' = w$ very nearly.

Whence equating the two values of w, and reducing, we obtain

$$t = \frac{r}{3gs'} \frac{31}{100} \frac{1-s}{17} \text{ whence substituting values } t = \frac{1}{28124} \text{in.}$$

has been obtained of a thickness not exceeding one two-millionth of an inch, while gold leaf itself is exceeded slightly by the thinness of the film of the black spot I have described as being formed on the upper pole of an undisturbed bubble, which has probably a thickness even less than three eight-millionths of an inch. When we consider that this film yet contains only about a fiftieth of its weight of soap, a substance of highly complex atomic constitution, we obtain some notion of the almost infinite divisibility of matter.

Thin as is the film that forms our bubbles, yet its equality of tension is such, that by dexterous management they may be



blown to a giant size. For this purpose the tobacco-pipe must be discarded, as it neither gives a large enough film to commence with nor supplies air with sufficient rapidity. A small glass funnel, of about 1¼ in. in diameter, cemented by some marine glue, with its mouth downwards, into a glass tube connected with a double-action bellows, must be employed. The connection between the tube and bellows should be made with a caoutchouc tube, and supplied with a stop-cock or clamp for regulating the supply of air. A small flat basin, containing some of the bubble solution, should be employed to form a film across the mouth of the funnel, which is then expanded by careful supplies of air from the bellows. When the bubble has

attained a considerable size it can be supplied with more material by carefully moistening the edges of the funnel with a small brush dipped in the solution. By these means the size of the bubbles can be increased to a wonderful extent (on one occasion a diameter of 1 ft. 7 in. was attained), and an object produced, of whose splendour and beauty no description can give an adequate idea. Its great globular surface has spaces of large extent blazing with one particular tint, to which the colour of another part vies in contrast, and the whole produces an effect which is well worth some pains to procure. This experiment should be performed in as still an atmosphere as possible, since the larger the surface of the bubble, or rather globe, the more sensitive it becomes to injury from currents.

There are so many other interesting experiments to be obtained from our toy, that it would be easy to fill many more pages with their description and discussion; but I will now only describe one more, which is the most fascinating of all. This consists in harnessing the bubble, and thus making it an actual balloon. This is a matter so easy of performance, that the only wonder is that it has not been done long ago. The following is the method :—

Take some foreign post paper, not too highly glazed, and cut out a circle of the size A; then by means of sealing-wax attach a piece of fine thread to the centre, using as little wax as is consistent with a secure attachment. Allow the paper disc, thus prepared, to steep for some time in the bubble solution, until thoroughly moistened, and it is then fit to attach to the bubble. For this purpose, blow a small bubble with the tobacco pipe, and bringing the surface of the moistened paper disc gently against the bubble by means of the thread, in the manner of a boy's sucker, it will immediately adhere, without at all affecting the health of the bubble, which can be blown to its usual size, and gently detached from the pipe. It will then remain attached to the thread, and can be swung about at pleasure. When this process has been managed with care,

there is no difficulty in blowing a bubble by means of a coal gas supply (using a caoutchouc tube for connection), and attaching the disc as before, detaching it from the pipe as soon as it has attained a considerable ascending power.

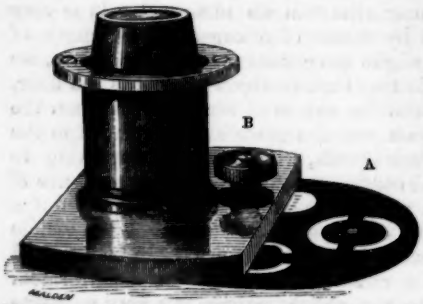
Under these circumstances it can be carried about at will, floating in the air as high as the thread will allow, forming the most delightful plaything that can be imagined. It is very amusing to balance it by means of a considerable length of thread, preserving a slight preponderance of the latter, so that it slowly sinks. It may then be thrown towards the floor, to which it descends until the excess of string rests upon the ground, when the balloon remains gracefully suspended in the air, waving about at each breath, without at all appearing to suffer from its shackled condition. The unusual appearance of such a balloon has a singular effect, which is increased if a fibre of unspun silk be employed in the place of the visible thread. In the same manner a car of silver foil can be attached to the paper disc, and a miniature balloon ascent performed. A balloon suspended in the above manner is a very sensitive indicator of air currents. On this property a most interesting experiment can be performed by placing in the middle of the room a burning lamp, and bringing a balloon, nearly counterpoised with excess of thread, within its influence, when it will be slowly drawn towards the lamp, and will then immediately ascend with the current of convection, as though it would be dashed against the ceiling; but not so, it will be carried round by the current, after an apparently hair-breadth escape, and will descend in the stream of colder air, only to be again dragged towards the lamp to perform the same round.

These are only a few of the illustrations of natural laws that may be obtained by means of our plaything; but the above descriptions will enable the reader, if he care to repeat them in a practical form, to devise many more, and to share in the pleasure and instruction these experiments have afforded the writer.*

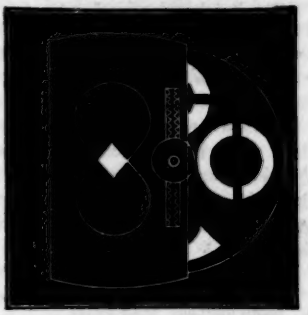
* The solutions whose preparation is described above may also be obtained of Mr. Ladd, optician, Beak-street.

MR. HIGHLEY'S CONDENSER.

Mr. Highley has devised a modification of Webster's condenser, which possesses some very striking and important advantages. The drawing which we append shows the form of the instrument. Its optical part consists of "a double concave lens cemented to a very deep crossed lens," and the mechanical arrangements are efficient and complete. The advantage of this new condenser over the old patterns is not that it is superior to them under all conditions; indeed, for some purposes, Powell and Lealand's form, with its enormous angle of aperture, would be preferred; but the Highley condenser meets a greater number of everyday requirements than any other condenser yet produced. It works well with powers from one inch upwards to the highest. When very low object-glasses, such as three inch, are used, it must be removed whether light or dark ground illumination is desired; but the greater majority of microscopic observations are made with powers of from one inch upwards, and for these the new condenser is very efficient. With an inch or two-thirds, for example, it affords an excellent light ground illumination, instantaneously changed to a good dark ground one by moving the circular diaphragm carrying the stops. If a quarter or even a one-twentieth has to be employed, the condenser need not be changed, as it works well with high powers, bringing out delicate diatom markings, and the wedge-shaped patterns on the Podura scale, with the light marks so admirably shown in Mr. Richard Beck's engravings.



Mr. Highley's Condenser.—Upper side, showing the revolving diaphragm A, and the milled head B, which opens or closes the shutter shown in the under view.



Mr. Highley's Condenser.—Under side. The lozenge-shaped opening represents the shutter partially closed, and shutting off peripheral rays.

If a student had a complete set of illuminating apparatus, including Powell and Lealand's large angled condenser, the parabolic illuminator, etc., etc., we do not say that for some special objects he would not avail himself of these contrivances in preference to Mr. Highley's; but the latter has the great practical advantage of being adapted to a wider range of power and purposes, and is thus calculated to save an immense deal of trouble and loss of time in shifting apparatus.

The distance of the condenser from the object is regulated in the best pattern of Mr. Highley's condenser by a rack adjustment; and in addition to the set of stops in the circular diaphragm, he has introduced a double shutter on the plan of Mr. Collins' clever adjustible diaphragm, which appears, as we before stated, to be a revival of an arrangement of Dolland, for which Mr. Collins deserves much credit.

This shutter, by varying the size of the aperture, is intended to correspond in action with the series of round holes in the diaphragm of an ordinary condenser. To some extent it does so perfectly, and it will be found very useful; but a small stop only admitting central rays in the ordinary pattern appears to us preferable on some occasions. The abruptly-rounded form of the bull's-eye in Mr. Highley's contrivance is not favourable for the transmission of a small pencil of central rays only; and when trying to make it answer this purpose, we have not succeeded in avoiding a certain amount of glare.

The new condenser requires a little practice, and some deviation from the mode of using the old condenser, to work well. Thus we have obtained the best definition of the Podura scale by using a central stop, and partially closing the shutters of the diaphragm. A stop which admits light from a half-circle of the margin of the lenses only, is very useful for many purposes, and as all the stops are large it is often desirable to try the effect of throwing them out of centre so as only to use portions of them.

We feel convinced that microscopists will appreciate the new condenser, and it will save many a student from the necessity of purchasing several distinct pieces of apparatus, costing in the aggregate a great deal more money than the price of Mr. Highley's instrument.

M. CHACORNAC ON THE MOON.—OCCULTATIONS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

THERE has probably never been a time since the invention of the telescope when selenography has received so much general attention as at the present moment; and on this account our astronomical readers may be interested in learning the conclusions which have been deduced as to the nature of the lunar surface by the eminent French astronomer, M. Chacornac, to whose care has been consigned the great silvered-glass Foucault speculum of about 2½ English feet in diameter, and who is carrying on his observations at Ville-Urbanne, near Lyons. What aperture and power he may have used does not appear; or, indeed, whether this particular instrument was employed in his researches; but they who have tried the effect of only twelve inches of silvered glass will not readily suppose that the whole of that magnificent mirror could have been used to collect the lunar rays.

This celebrated observer begins by telling us, what was stated many years ago as the experience of English astronomers, that the forms of the lunar craters become less regular when scrutinized with great optical power; he finds that their structure then appears more similar to that of analogous terrestrial formations than might have been previously supposed, and considers that astronomers may undertake an "orographical" examination of our satellite, as geologists have done of the primary planet. The disadvantage is indeed great of having to contemplate objects at a distance of 240,000 miles, and instead of distinguishing strata by the microscopic shells which they contain, being obliged to reckon upon 120 yards as the *minimum visibile* in lunar dimensions. It is, however, somewhat counterbalanced by the opportunity of comparing in a single view the formations of an entire hemisphere. Much may be learnt from shadow, as to the minuter details. There are steppes in Central Asia, where, from the uniformity and whiteness of the soil, the shadow of a man at sunset visibly lengthens his stature one hundredfold; and such is the case on the moon. No sensible penumbra attends the shadows there, and owing to the absence of reflected light from an atmosphere, they are clearly defined, and, under a very low angle of illumination, give us intelligence of many irregularities of form, too minute for direct observation. By such an examination we become acquainted with the fact, that the lunar surface falls naturally into two contrasted divisions. The surface in relief, which has always been

considered analogous to the continents of the earth, is clearly distinguished from the level portion by its porous structure and its great reflective power, as well as by its elevation; while the other is sombre and smooth, and presents, as Sir J. Herschel has said, a completely alluvial character. Nevertheless, there is nothing whatever to justify the ancient appellation of *seas*, and the expression *alluvial* is employed only in default of a more appropriate term. In fact, there is not the slightest appearance of any fluid, or body susceptible of evaporation, on the lunar globe, though every portion of it is exposed to the direct solar radiation during 343 consecutive hours. The surface of the continents everywhere displays a character of eminently volcanic, or, at any rate, igneous origin. For example, in the lunar *Caucasus*, *Apennines*, and *Alps*, we find a region overspread with little hillocks in very close proximity, giving the aspect of a soil violently agitated by a species of ebullition followed by rapid cooling. In other districts the volcanic continent appears ruined to such a depth by the multiplicity of craters, that they have broken out in each other's interiors. In the S. part of the disc, it is not uncommon to observe three or four contiguous rings, which have overthrown and defaced one another in succession; for instance, the exhausted soil of the craters *Metius* and *Fabricius*. The raised portion of the continents has everywhere a rough, rugged, puffy character, resembling that of iron dross; the rounded hill-tops, as well as the crater-rings, are perforated by a multitude of little cavities and pits, indicating a kind of most vehement ebullition. The walls and environs of *Metius* and *Fabricius*, which may be cited as types of this sort of formation, are so "riddled" by these perforations, that they appear, under an oblique illumination, to possess a structure exactly like that of the most porous pumice-stone. In some neighbourhoods the strictly volcanic character predominates, in others the more rounded mountainous aspect; but the continental regions never offer the smooth, uniform appearance of the so-called seas, whose aspect is that of hardened plaster, or, still more accurately, that of immense plains of dried mud.

From these strongly-marked physiognomical characters it is possible to recognise regions to which the same origin may be ascribed, even though they may be separated by a vast extent of the so-called alluvial plains.

These two kinds of surface are more intermingled than the terrestrial continents and seas: in the centre of the enormous levels which form more than two-thirds of the visible hemisphere of the moon, we meet with numerous archipelagos and unnumbered islets, apparently the remains of ancient continents

buried beneath the maritime soil; and, besides these, we find, at the line of junction of the two kinds of surface, very curious appearances of "erosion" and submersion of the shore, perfectly analogous to that of the Island of St. Paul, in the Indian Ocean. To render this more intelligible, we may remark a characteristic distinction between the usual form of the lunar and the terrene crater. The latter generally occupies the top of a conical mountain, and the bottom of the cavity is never far beneath the summit; the depth of the crater being only a small fraction of the height of the mountain. On the contrary, the bottom of the lunar crater, in its original condition, is always deeply depressed below the level of the soil on which the cone of eruption is raised, so as to give it, when of small dimensions, some analogy with a vast conical well. In studying, for instance, those of not more than 300 to 1000 yards in diameter, and having a continuous ring, we come to the conclusion that this is the result of a single explosion, which raised the surface in the form of a bubble, and deposited it round the orifice of eruption. But, to return to the phenomena of encroachment to which such formations have conduced, we find on the "sea-shores," and especially where the higher ground sinks by a gradual declivity, the interiors of certain partially-destroyed rings filled up by a compact mass of alluvial soil, precisely as the bottom of the crater in the Island of St. Paul is now invaded by the ocean. In such cases the shore takes the form of a vast semicircular bay, whose entrance is partly obstructed by the remains of the ring, exactly as is the case with the terrestrial volcano in question. In examining these extremely striking and interesting details, we shall meet with what may be compared to marshy formations, immense partial inundations, the complicated particulars of which are not within the compass of this sketch: these marshy formations consist principally of volcanic hills, whose bases are covered by sedimentary soil; but the most important fact connected with them is the presence of other neighbouring craters, which, though on the same level, are entirely empty, with outlines usually unbroken, and interiors excavated considerably beneath the marine surface, affording a singular contrast to the ruined aspect of the buried craters. The one have nothing left standing but the thickest portion of their ramparts, and projections bearing the marks of erosion; the ejections of the other exhibit themselves regularly around the cone of eruption as currents of lava, preserving the smallest details of their edges, and winding and spreading along the shallow depressions of the plains: so that it is perfectly evident that these latter craters have been formed subsequently to the consolidation of the ground which supports them, and which in

turn has moulded itself upon the cavities of the more ancient eruptions.

As types of each of these forms, completely different and characteristic of successive epochs of formation, we may refer to *Herschel* or *Alpetragius*, and *Ptolemæus*. These show especially the ordinary diminution of magnitude of the more recent as compared with the buried craters. In fact, the diameter of *Ptolemæus* is more than forty, while that of *Herschel* is less than four leagues, although the height of the eruptive cone of the latter is more than 200 metres higher than the loftiest peak of *Ptolemæus*;* while the minute exploration of the "sea-shores" proves that in all cases where the continental ground has offered an accessible opening, an influx has taken place from without, and the adventitious material has risen there to the general level which it preserves [sufficiently, at least, for the present argument] throughout the visible hemisphere.

Among the numerous results of this kind of general *diluvium*, we discover, in an immense number of points on the plains, evidence of the subsequent levelling of igneous products; and these levellings are the more distinguishable for three reasons: the continents have a much greater reflective power than the *maria;* their relief is usually very marked and sharp; and their structure, whether as mountains or craters, always has a circular type and a scoriaceous consistency; while, on the other hand, the slight protuberances of the *maria* are merely oblong hills of slight elevation, and uniform [general ?] rectilinear direction. The configuration of these hills, whose material is exactly similar to that of the plains, is perfectly comparable to the ridges of sand thrown up by our tidal waves on broad, sandy beaches. The linear shape of these slight undulations, together with the difference of their structure, leaves no doubt as to the nature of the emergent spots, marked by strong relief and sharp outlines, which occur scattered in the centre of the lunar oceans.

Among other characteristics of the primitive surface, we notice immense rings, whose crests alone project above the surrounding plain by some hundreds of yards—circular ramparts, the last visible vestiges of great buried craters: and these are cut through by considerable breaches, which permit us to follow the level of the maritime soil where it penetrates their interiors, and to remark the absence of the slightest difference in surface or structure. We might suppose that we were looking upon the remains of an archipelago similar to the Phlegrean Fields, invaded by a fluid but subsequently conso-

* The French league is very nearly equal to 2½ English miles. The French mètre is 3 feet 3·37 inches, English measure.

lidated mass. We may refer to the two rings, *Kies* and *Lubiniezky*, as curious types of this formation. Each of them has ramparts of about forty-five leagues, rising sharply in the midst of an immense desert to a height of two or three hundred yards.

It is known that while some craters exhibit only a simple cavity, others possess a central peak. We may further remark that in the heart of the continents flat-bottomed craters exist, the peaks of which, half-emergent from the sedimentary mass, demonstrate that the craters have been invaded by maritime soil; and we may notice cases where all traces of central peaks have disappeared beneath thick beds of deposited matter.

To give an idea of the gigantic proportions which characterize this kind of formation peculiar to our satellite, M. Chacornac specifies the crater *Schikard*, lying towards the S.E. limb; the interior, which is upwards of sixty-five leagues in diameter, would have to a spectator in the centre the aspect of a boundless desert; as the speedy rounding-off of so small a globe would depress the rampart out of sight in every direction, though attaining on the N. a height of more than 10,500 feet.

After this brief examination, it remains to point out a fact enabling us to class the craters of different dimensions in a chronological succession. In a great number of craters such as we have just described, we find that a portion of their bulwarks has disappeared from the effects of subsequent eruptions, whose foci have broken out even through the ring itself, and produced craters, usually entirely empty; and the more recent date of these outbreaks is also proved by there being no trace of the destroyed portion of the ring, while the ejected products of the more modern are superimposed on those of the earlier crater. The dimensions, also, of the encroaching basin are always inferior to those of the original cavity. This, which is characteristic of the lunar formations, may be considered as a general law [almost?] without exception.

We may distinguish, then, three clearly marked selenological epochs. The primitive is that during which immense vesicular upheavings have given rise to crater-like rings of more than 300 leagues in compass, and around which we perceive clear traces of entangled circumvallations [*circonvallations enchevêtrées*]. To this period would have succeeded that of a general diluvium, forming deposits analogous to the alluvial strata of the earth. This effusion has buried, under a brown mass, more than two-thirds of the visible surface of the moon, including the interiors of all the great craters, displaying itself from one extremity of the hemisphere to the other, apparently on the same level. Subsequently to this second period came

on, in every direction, and through every kind of surface, a multitude of eruptions, producing small deep craters resembling conical wells, whose interiors are entirely free from all alluvial deposit. Finally, in the intervals of these three great epochs, other phænomena are met with, which, M. Chacornac informs us, will form the subject of a future communication. In conclusion, he states his opinion that this great diluvium was probably due to the precipitation of the gaseous matter of the lunar atmosphere; the cooling of the globe having proceeded to a certain extent, atmospheric pressure would favour the precipitation of gases and vapours in the form of an universal rain, filling up the great craters, and followed by a process of sedimentary consolidation.

It will be evident that an objection to this very ingenious and striking selenological theory will be found in the sharp and precipitous aspect of many of the great ancient rings, whose angular relief ought to have suffered more serious degradation from the loss of so much sedimentary matter as would have been expended in filling up their interiors without external communication. *Plato* and *Archimedes* may be cited as prominent instances. It may be thought, too, that there is so gradual a transition from the broad flat ancient wall-plains to the deeply-hollowed concavity of the more modern craters, that it can scarcely be brought into accordance with the supposition of such clearly separable epochs? Nevertheless, the memoir is of so interesting a character, and proceeds from such high authority, that we feel sure our readers will be glad to have it placed before them, and will look forward with pleasure to future communications from its eminent author.

OCCULTATIONS.

Dec. 3rd, 130 Tauri, 5h. 14m. to 5h. 38m.—6th, A^3 Cancri, 8h. 12m. to 8h. 48m.

AIDS TO MICROSCOPIC INQUIRY.—No. VIII.

Honey.

Among the objects which are common in family stores, honey may be mentioned as capable of affording considerable microscopic entertainment.

The bees obtain from the nectaries of flowers a number of substances which may be recognized in honey—a substance composed of different kinds of sugar, a small quantity of gum, mucilage, a little wax, an acid, pollen grains, etc.

Sugars are compounds of carbon, hydrogen, and oxygen. *Cane sugar*, or the sugar in common household use, consists of twelve parts of carbon and eleven each of hydrogen and oxygen. It is very soluble in water, crystallizes in four or six sided rhomboidal prisms, and acts upon polarized light so as to produce a right-handed rotation.*

If the elements of water—one equivalent of oxygen and one of hydrogen—are added to cane sugar, *Fruit Sugar* is produced, which does not crystallize, is more soluble in dilute alcohol than cane sugar, and produces left-handed rotation of polarized light. In this sugar we have twelve equivalents each of the three components—carbon, hydrogen, and oxygen. A third kind of sugar contains two equivalents of water added to fruit sugar. This is *Grape Sugar*, found in dried fruits. It crystallizes in cubes or square tables, is less soluble than cane sugar in water, but more so in alcohol, and produces right-handed rotation. Another kind of sugar, *Sugar of Milk*, contains fourteen equivalents of carbon, nineteen of hydrogen, nineteen of oxygen, together with five equivalents of water. It crystallizes in four-sided prisms, is not, like those previously mentioned, directly susceptible of alcoholic fermentation, and produces right-handed rotation. There are several other sugars, which will be found described in *Miller's Chemistry*, from which the preceding information is condensed.

* Suppose the experimenter to use two Nicol's prisms, one as polarizer and the other as analyzer, bodies capable of inducing circular polarization will, when inserted between the prisms, twist the plane in which the light vibrations take place. The explanation given in *Ganot's Physics*, translated by Atkinson, is as follows:—"When a ray of homogeneous light traverses the first Nicol, it becomes polarized in a plane at right angles to the principal section. Its vibrations are all in the plane of the principal section, and therefore are not transmitted by the second Nicol when the planes of the two principal sections are at right angles to each other. But by passing through a plate of quartz (a substance capable of producing rotation) in the direction of the axis this is changed: the plane of vibration experiences a uniform rotation in such a manner that its path becomes that of a screw rotating round the axis of the crystal." Some substances cause this screw to have a right-handed twist and others a left.

The sugars mentioned vary in sweetness. Cane sugar is the sweetest. Fruit sugar, which is abundant in treacle, comes next. Starch sugar or grape sugar is so inferior in this property that, according to Professor Miller, two and a half pounds of it only produces as much sweetening as one pound of cane sugar. Milk sugar comes lowest of all. It should be stated, in reference to fermentation, that, when cane sugar is acted upon by yeast, it is converted first into fruit sugar and then into carbonic acid and alcohol.*

Honey contains a great deal of the uncrystallizable fruit sugar, and, when quite fresh, is, as is well known, a transparent liquid. When removed from the comb, part of the sugar soon passes into the form of grape or starch sugar, and crystallizes in patterns more or less like the four or six sided prisms of cane sugar.

If, therefore, a little drop of honey, that has been some time out of the comb, is placed upon a slide covered with thin glass, and viewed with an inch or two-thirds objective, it will be seen to contain a great quantity of more or less perfect sugar crystals, which become splendid objects with polarized light and the use of the selenite stage.

In addition to the sugar crystals, grains of pollen from the plants which the bees have visited will be discerned, and it is interesting for those who live in the country to collect pollen grains for themselves, and compare them with those introduced into the honey by the bees.

Honey, adulterated with potato starch, will be detected by the form of the starch grains, and by the cross they give with polarized light. When common sugar is added to restore the sweetness of adulterated honey, Dr. Hassall tells us it may be detected by the thicker and clumsier crystals which it forms.

When bees have access to odoriferous flowers, their honey acquires a special characteristic, which is often exceedingly pleasant. They sometimes visit poisonous plants, and then their honey has deleterious properties, like that which affected Xenophon's soldiers in one portion of their famous march. This sort of honey, partially made from the *Azalea pontica*, possesses in our times the same undesirable qualities.

* *Vide Miller's Chemistry.*

HEART MOVEMENTS GRAPHICALLY DISPLAYED.

BY M. MARCY.

Comptes Rendus, No. 19 for this year, contains a paper by M. Marcy detailing some curious investigations made with an instrument which makes a mark on paper each time it receives a shock from the movement of the heart of any animal against whose chest it is placed. In man the resulting diagram exhibits a number of pointed conical elevations, with recurring irregularities in the ascending and descending lines. The irregularities in these figures mark the motions belonging to the contraction of the auricles, the contraction of the ventricles, and the movements of the valves.

Quite a different form is drawn when the instrument is applied to the land tortoise (*Testudo Europea*). The ascending line is simpler. First a sloping line indicates the contraction of the auricle, then the line ascends nearly vertically to a considerable height to mark the contraction of the ventricle, which, as it gradually subsides, makes a gently descending line longer than the corresponding part of the ascending one. This repeated in succession gives a pattern in which what we may call broad tablelands alternate with deep, open valleys. The heart of the frog impresses upon the instrument a tremulous series of rounded, zig-zag lines.

M. Marcy tried several fishes, amongst them a ray (*Raia alba*), and the pattern yielded was in appearance between that of man and that of the frog.

Crabs, lobsters, etc., afforded a very curious diagram. M. Marcy says, "In these creatures, by reason of the absence of an auricle, we find a single very powerful contraction, that of the ventricle." The figure consists of a repetition of a short horizontal line, then of a long one ascending almost at right angles, then turning over, and descending as abruptly.

The great pecten or scallop afforded a regular figure, consisting of a zig-zag of long descending and short ascending lines, sloping from left to right. The force and duration of the contractions being much less than in the case of the crab, as might be expected from the lower position of the animal.

COMETS.

AN ACCOUNT OF ALL THE COMETS WHOSE ORBITS HAVE NOT BEEN CALCULATED.

BY G. F. CHAMBERS.

(*Continued from Page* 307.)

1702. [i.] Numerous navigators report seeing a comet in the southern hemisphere, between February 20 and March 1. On February 28 the tail was 43° long. At 8h. p.m. in latitude 15° 10′ N. and longitude 116° 45′ the comet bore S. of W. 20° 30′, altitude 8° 40′. On all occasions it was seen in the evening after sunset. Maraldi, at Rome, saw the *tail* for several days at the end of February and beginning of March. —(Struyck, *Vervolg*, Amsterdam, 1753, p. 50.)

1733. On May 17 and 18, a comet was seen by several navigators off the Cape of Good Hope, in the N.W.¼W. quarter.—(Struyck, p. 61.)

1742. [ii.] On April 11, a comet is recorded to have been seen in the S.E. by several Dutch navigators, at sea, off the Cape of Good Hope. On April 14 the tail was 30° long.—(Struyck.)

1748. [iii.] On April 24, a Dutch navigator, at the Cape of Good Hope, saw a comet at the beginning of Aries, rise in the E.¼N.E. at 4h. a.m. This is probably the comet (rendered invisible at the Cape by a northerly motion) which Kindermanus saw on April 28, at 2h. a.m. at an elevation of 8° above the horizon, in a straight line with δ and α Trianguli and the lighted star of Aries, in longitude 80°, latitude + 28°, and declination + 50°. On May 3, between 11h. and midnight, the comet was near Perseus, and within the circle of perpetual apparition.—(Struyck, p. 100.)

1750. Between January 21 and January 25, Wargentin observed a comet below ϵ and θ Pegasi.—(*Tables Astronomiques de Berlin*, i.)

1783. On December 18, Sir W. Herschel observed a nebula 1m. preceding δ Ceti and ½° N. of that star. He describes it as small and cometic. In his son's great catalogue of 1864, this object is set down as really a comet, not having been since found, though looked for.

1808. [i.] On February 6, Pons discovered a small faint comet between the neck of Serpens and Libra. It was only visible three days, becoming lost in the moonlight. Its movement was rapid and towards the S.—(*Astron. Nach.*, No. 149, vol. viii.)

1808. [iv.] On July 3, Pons discovered a comet in Camelo-

pardus: it was observed only on that night and July 5. The position on July 3, at 15h. 4m. 26s. Marseilles M. T., was R. A. 3h. 10m. 10s. and Decl. + 56° 36′. On July 5, at 15h. 8m. 58s. the R. A. was 3h. 31m. 46s. and Decl. + 58° 19′—(*Monatliche Correspondenz*, xviii. 249.)

1839. On July 14 and 17, an extremely faint comet was observed at the Roman College. It was in Draco, and appeared like a double nebula, or as if doubled into two branches. —(*Memoria Oss. Coll. Rom.*, 1839.)

1846. [ix.] On October 18, Hind observed a comet in Coma Berenicis for more than an hour. Its altitude was low, and being in the morning twilight it was never seen again. Its exact position at 16h. 15m. 11s., G. M. T., was R. A. 11h. 59m. 49s.; Declination + 14° 59′ 32″. Its motion was increasing in R.A. at the rate of about 4m. a day, and diminishing in Declination at the rate of about 11′ a day.—(*Month. Not.* R.A.S., vii. 162.)

1849. [iv.] On November 15, being at sea, in latitude 10° S. and longitude 30° W., the Rev. J. M. Jenkins and others saw a comet, with a nucleus, as bright as Mars, and with a tail curved and pointing to the S.W. It was also seen on November 28.—(*Month. Not.* R.A.S., x. 122 and 192.)

1854. [i.] On March 16, a bright nebulous object was seen by Brorsen. Its position at 8h. 15m. 34s. Senftenberg M. T. was 2h. 30m. 12s., and Declination + 1° 11·2′.—(*Astron. Nach.*, 897, vol. 38.)

1856. [i.] In January, a comet was seen in the N.W. sky at Panama.—(Letter in the *Morning Herald*.)

1856. [ii.] On August 7, an object, supposed to be a comet, was seen in Virgo, by E. J. Lowe.—(*Month. Not.* R.A.S., xvii. 114.) A comet was also seen at Arequipa, in Peru, for a fortnight previous to August 21, for two hours after sunset.—(Letter in the *Times*, October 8, 1856.)

1859. In February, a very faint comet was seen, by Slater, in R.A. 11h. 48m.; Declination + 19° 49′. He saw it again on May 7 and 22, when it had become fainter, not being visible with any aperture below 11½ inches. Its movement was very slow, and seemed to be in a northerly direction.—(*Month. Not.* R.A.S., xix. 291.)

PROGRESS OF INVENTION.

AVENTURINE.—This beautiful substance, which has long been an object of imitation, is a species of quartz, that contains throughout its mass a number of brilliant spangles of mica. The Venetians very early succeeded in producing a compound which rivalled that formed by nature; and as they preserved the secret of its manufacture, it continued to form a lucrative article of commerce. A mode of making a kind still more exquisite than the Venetian has been recently discovered by M. Pelouze. The spangles in the Aventurine manufactured in the glass works of Venice consist of metallic copper, the mass being tinged throughout a delicate brown, by oxide of iron; and an excellent imitation was obtained by MM. Fléury and Clemandot, by keeping fused, at a high temperature, for twelve hours a mixture containing three hundred parts pounded glass, forty parts protoxide of copper, and eighty parts oxide of iron, and then allowing the mass to cool very gradually. The Aventurine of M. Pelouze is of a light green tint, which is much more pleasing than brown, and is produced by bichromate of potash. He fuses together two hundred and fifty parts fine sand, one hundred parts carbonate of soda, fifty parts carbonate of lime, and forty parts bichromate of potash. The latter is decomposed by the heat into oxide of chromium, and neutral chromate of potash; and the neutral chromate is decomposed by the silex, silicate of potash and oxide of chromium being formed, and oxygen liberated. If an excess of bichromate is employed, the transparency of the product is impaired, and brilliant spangles of sesquioxide of chromium are diffused through it. When the proper proportions are used, the artificial gem obtained yields only to the diamond in lustre; it is hard enough to cut glass, and yet it is worked with great facility. To distinguish it from that obtained at Venice, it has been properly termed "Chrome-aventurine."

THE NATURE OF AMMONIA.—It has been for some time a question whether or not ammonia is the oxide of a metal presumed to consist of H_4N. The strongest argument in favour of its metallic nature has been founded on the fact that an amalgam of mercury may be obtained by means of ammonia. The argument derived from this has, however, been rendered extremely doubtful by the researches of Dr. C. M. Wetherill. The so-called ammonia amalgam possesses physical properties exactly similar to those of the other amalgams; but they are found accompanied by one of a suspicious character—the mass gradually shrinks *of itself*, and becomes resolved into ammonia and mercury. It appears certain, from the experiments of Dr. Wetherill, that the so-called amalgam is merely a mixture of ammonia, sodium amalgam, and mercury, swollen up by the bubbles of hydrogen set free during the process used in forming it, and retained by some of the sodium amalgam used as a medium from the production of the amalgam of ammonia. The sodium is thus kept out of contact with the solution of ammonia salt; but it becomes gradually oxidized, and the swelling subsides. That such is the nature of the product obtained appears certain; since the hydrogen to

which the effect is due has been actually obtained. More compression, by squeezing out this gas, destroys the amalgam, leaving a film which has the appearance of lace, on account of the space which the bubbles of hydrogen had occupied; and finally the formation of the amalgam depends on its capability of being swollen up by the gas, since the more fluid the sodium amalgam the more effective it is in producing the supposed amalgam of ammonia. The question regarding the nature of ammonia is more important even than, at first sight, it would seem; since, if ammonia is the oxide of a metal, we may fairly conclude that many other of the metals, if not all of them, are compound bodies; and if they are compound, it must be possible to form them artificially; in which case the alchemists were not the visionaries they have so long and generally been considered.

Economic Productions of Pyrogallic Acid.—In practice only twenty-five per cent., or one third of what might be expected from theory, of pyrogallic acid is obtained from gallic acid. This loss, from the imperfection of the process employed, is very serious, as the quantity of pyrogallic acid now used, especially by photographers, is great. Attempts were made by various chemists of great eminence to prevent this waste, but with only partial success, until M.M. Victor de Luynes and G. Esperandieu devised the improvements, which they have recently brought under the notice of the Academy of Sciences. The waste which occurs with the ordinary process arises—as it often does in similar cases—from decomposition occurring at the very temperature required for production, and is therefore proportional in amount to the time required for the manipulation. It is avoided by the method of M.M. de Luynes and Esperandieu, who decompose the gallic acid, by subjecting it to the action of bases, or even of pure water, in close vessels. They introduce the gallic acid, along with two or three times its weight of water, into a bronze boiler, and heat it to between 200° and 210° Cent. Having kept it at this temperature for about half an hour, they allow it to cool; then boil the resulting pyrogallic acid, which is almost colourless already, with animal charcoal, filter, and evaporate at an open fire, to drive away the water. On cooling, amber or rose-coloured crystals are formed—they would be white if the distillation had been effected *in vacuo*. The quantity of pyrogallic acid obtained in this way is fully equal to that which theory would lead us to expect; and the quality is quite as good as that ordinarily obtained by sublimation. This method was first used by Pelouze, but was not, until now, applied to commercial purposes.

Light as a Source of Motion.—Although it has been known for some time past that light is capable of producing mechanical effect, the amount of this effect was unknown; it has, however, been determined by Professor Thomson of Copenhagen, by changing the light into heat, the mechanical effect of which is easily calculated. To free the beam of light, which he examines, from all calorific rays, he passes it through a layer of water; and, when it is afterwards transmitted to the thermo pile, the deflections of the needle accurately indicate its heating power. During these experiments certain dis-

turbing circumstances came into operation, but their influence was calculated and allowed for. Thus the water absorbed, not only the calorific, but 0·13 of the luminous rays also; six sevenths of the radiant heat and light of a flame are carried away by the heated air —the amount being modified, however, by the intensity of the heat and light. Light obtained from various artificial sources was used; and it was found that a flame, the intensity of which is equal to that of a candle which burns 8·2 grammes of spermaceti per hour, radiates per minute, light which, if changed into heat, would raise the temperature of 4·1 grammes water, one degree Cent. It has been calculated, from the results afforded by these experiments, that the light emitted by the sun would lift thirty-five billions of tons one billion of kilometres high per second, and that it would raise the earth twenty feet in the same time.

FERROSUM AND FERRICUM.—The striking difference between the salts of the protoxide and those of the peroxide of iron has always attracted the attention of chemists; but, until recently, it was not suspected that they were in reality salts of metals which, except that they are capable of being converted into each other, are as different as they could be. Berzelius first ascertained their separate existence: he termed that found in the protosalts *ferrosum*, that found in the persalts *ferricum*. These allotropic states of iron are as different in their properties as the two varieties of phosphorus, or those of sulphur. Their atomic weights are not the same; that of ferrosum being 28, and that of ferricum 56. The one combines with a single atom of oxygen, the other with not less than three. Hitherto only ferrosum had been obtained. M. de Cezancourt has demonstrated the existence of ferricum in the metallic state; and during his researches on the subject has discovered facts which may have a serious influence on the iron manufacture. Before he proved the contrary, it was believed that cast iron, steel, and wrought iron, differed only in the quantity of combined carbon: although it had been observed that their properties were not always in accordance with their constitution. Specimens of cast iron of the very same composition are often very dissimilar in quality and appearance; cast iron and steel sometimes contain the same elements in the same proportions; specimens of steel and malleable iron are found occasionally, of the very same composition. M. de Cezancourt has ascertained that, in reality, the difference is due to the degree of oxidation in which the iron exists in the ore. The salts of the protoxide furnish one kind of iron, and those of the peroxide another. Different ores will furnish different kinds of iron or steel, according as they contain ferrosum or ferricum, or both. Malleable iron contains a mixture of ferrosum and ferricum, the ferrosum being changed by a high temperature into ferricum: and its quality is dependent on their relative amounts. Steel, if stable, and of a good kind, contains ferrosum and ferricum in the proportion of their atomic weights; and hence magnetic oxide of iron will afford excellent steel. In black and grey cast irons, the ferricum has abandoned, while cooling, the charcoal it dissolved at a high temperature; ferricum generally predominating in the grey.

In mottled cast iron, the ferrosum and ferricum retain their peculiarities; the white portions being formed by ferrosum in combination with carbon, and the dark by ferricum with its deposit of carbon. White crystallized cast iron consists of ferrosum in combination with carbon. Ferrosum is characterised by being obtained at very low temperature, and, when combined with carbon, is hard and brittle. The characteristics of ferricum are its abandonment of carbon, during slow cooling, and its malleability. It cannot by itself form stable steel; it requires for this purpose to be mixed with ferrosum, which passes into the state of ferricum without losing its hardness. Ferricum, unless it has been originally ferrosum, cannot be changed to it. The nature of the re-agents, and the degree of temperature used in the production of iron, modify the proportions of ferrosum and ferricum in the result. Thus oxide of carbon, which contains only one atom of oxygen, favours the production of ferrosum; bodies which, like phosphorus, combine with some uneven number of atoms of oxygen, not less than three, favour the production of ferricum. A low temperature tends to produce ferrosum, a high one ferricum. To obtain the best commercial iron, the nature of the ore, the re-agents, and the temperature must all harmonize. The employment of suitable re-agents shortens the time during which it is necessary to employ a given temperature, in order to obtain a certain kind of iron. The sudden cooling of steel causes carbon, which slow cooling would separate, to be retained in combination—with the ferrosum permanently, with the ferricum in such a way that subsequent tempering liberates it, and restores malleability. If the relative proportions of ferrosum and ferricum depend on the temperature and re-agents which have been employed in the manufacture, and not on the ore which has been used, they will be more or less unstable; and the quality of the iron will be impaired—slowly by time, and rapidly by repeated vibrations; which explains many causes of the breakage of axles, etc. There is reason to suppose that the calorific capacity of iron depends on the relative amounts of the ferrosum and ferricum which it contains; should such prove to be the case, calorific capacity may afford a simple and reliable test of the quality of iron.

New Galvanic Battery.—It has been found that a battery, the elements of which are silver and magnesium, is far more powerful than one of equal size consisting of copper and zinc. M. Bultinck found that when silver and magnesium, immersed in pure water, caused the galvanometer to be deflected temporally 90°, and permanently 28°, copper and zinc, in the same circumstances, caused a temporary deflection of only 30°, and a permanent one of only 10°. And when silver and magnesium were used, the same result was obtained with pure water, as when a dilute acid or saline solution was employed with copper and zinc.

Graphitic Acid.—This curious compound, which was discovered by Sir B. Brodie, has been recently examined by Dr. Göttschalk, who has discovered its constitution to be $G_{12}\ H_6\ O_{18}$. It is formed by heating pure graphite several times in succession with chlorate of potash, and the strongest nitric acid. The colour of the graphite

is not changed by the first heating: but the second, and those which follow, cause it to pass through various shades of green, until at length it becomes yellow. The process is then complete, and the graphitic acid obtained must be washed and dried in an exhausted receiver, or at a temperature of 100° Centigrade. It is in the form of very small transparent scales, which darken in the light: and is insoluble, except in water or alcohol, which dissolve only a very small amount of it. It may perhaps be used hereafter in photography, as paper which has been dipped in its aqueous solution becomes brown under the influence of light.

MISCELLANEOUS.—*Action of Light on Sulphuret of Lead.*—It has been observed that lead paint which has been darkened by the sulphuretted hydrogen found in the atmosphere, etc., is completely restored to its original whiteness by the action of light. The bleaching is very rapid if drying oil, and still more so if boiled oil, has been used in the paint. This fact proves how necessary it is that places where pictures are kept should be lightsome.——*Gun-Cotton and the Alkaline Metals.*—Gun-cotton will explode if either sodium or potassium is placed upon it; but not if a mixture of both. The discovery of these facts may perhaps lead to an explanation of the effects which the alkalies are known to produce on collodions.

ARCHÆOLOGIA.

THE fear of the CATTLE PLAGUE has lately so much weighed upon all classes of society, that it seems to have made itself felt even among antiquaries, and the opening meeting of the session of the British Archæological Association, on Wednesday evening, Nov. 22, was occupied by an amusing and interesting paper by the Hon. Secretary of that body, Mr. H. Syer Cuming, "On Charms employed in Cattle Disease." It would be an interesting, and far from an invaluable labour, to trace the history of the murrains, or cattle diseases of former days, and their causes and effects; but Mr. Cuming has treated only upon the means then employed for their cure, which, being the mere results of popular superstition, have, of course, no use in modern science and practice. Nevertheless, they furnish curious illustrations of the state of knowledge and intellectual development in the middle ages. The diseases of cattle were ascribed, by the peasantry in those ages, and even in much more modern times, to two agencies especially—to the malignity of certain classes of evil spirits, and to the influence of the evil eye. In the process of cultivating the ground, he frequently picked up the implements made of stone, which are now the object of so much archæological interest, but the real object of which the mediæval agriculturist could not understand, and he believed them to be ungodly weapons which the evil spirits hurled at his cattle, and which produced the dreaded and ruinous murrain. The fatal in-

fluence of the evil eye was an article of belief from the most remote ages. Superstition offered the preventive or cure, as well as the cause of the evil; and it is on this part of the subject that Mr. Cuming treats, in the paper read before the British Archæological Association. There is a sort of homœopathic feeling which seems to be natural to man in a state of ignorance, which leads him to suppose that a disease produced by such supernatural agencies would be best cured by the application of the instrument which had created it, and at least some forms of these stone implements, and stones of rare character unworked, were preserved carefully for this purpose. These objects were supposed to be the work of the fairies, who had imparted to them magical properties, which might be employed either by touching the diseased cattle, or by washing them with the water in which the magical amulets had been dipped. Mr. Cuming gave numerous anecdotes of this practice. The possession of such amulets was greatly coveted, and they were often set in silver. In Scotland, even so recently as the time of Pennant, that writer tells us that "Capt. Archibald Campbell showed me one —a spheroid set in silver—for the use of which people came above a hundred miles, and brought the water it was to be dipped in with them." These objects were sometimes balls of crystal. One of the most celebrated of these is in the possession of the Marquis of Waterford, and is said by traditionary legend to have been originally brought from the Holy Land. When pestilence appears among the cattle, this amulet is in great request, to be dipped in the water given the cattle to drink, or in a brook, through which they are driven backwards and forwards. Mr. Cuming exhibited several examples and drawings of these amulets, among which the most remarkable was the celebrated *Lee Stone*, or *Lee Penny*, which is said to have suggested to Sir Walter Scott the design of his "Talisman." According to the legend, Robert Bruce wished that, after his death, his heart should be carried to the Holy Land by Sir James Douglas, and in 1329, the latter, accompanied by Sir Simon Locard, of Lee, proceeded on the mission. In Spain, the Scots were drawn into a combat with the Moors, Douglas was killed, and Sir Simon, who now commanded the party, turned homeward with Bruce's heart, which was eventually buried in the abbey of Dunfermline. Sir Simon had taken prisoner a Moorish chieftain; and the wife of the prisoner, when she bargained for her husband's ransom, counting the gold from her purse, let drop this gem, and appeared so anxious to recover it, that Locard insisted on its being made a part of the ransom. The lady unwillingly consented, and informed the greedy Scot that its value consisted in its power in healing diseased cattle, and that it was also a sovereign remedy against the bite of a mad dog. So great was the popular faith in this "talisman" in Scotland, that the Lee Penny was excepted from anathema in the clerical war upon superstitions, after the Reformation; and the clergy went so far as to extol its virtues, which were resorted to for the cure of infected cattle until a very recent period. The Lee Stone appears to be the variety of cornelian agate called *hæmachates*—a heart-shaped pebble, measuring about half an inch

each way, set in a silver coin about an inch in diameter. There appears to be some doubt as to the character of the coin, but it is believed to be the Scottish groat, a coin which first appeared in Scotland under King David II. (1342—1371). The margin of the Lee Penny is pierced for the insertion of a silver chain, at the end of which is a ring, for the convenience of dipping it into the water to be administered to the cattle. Mr. Cuming, in the sequel of his paper, spoke of other charms employed against the cattle disease, which are so many proofs of the extent of the alarm to which it gave rise in former days.

On the same occasion, Mr. Kell laid before the meeting a collection of COINS, chiefly Roman, and a few other objects of antiquity, found in the ISLE OF WIGHT. The coins, as usual, ran through the Roman period, and the only remarkable circumstance connected with them is that there were among them a certain number of Greek coins. This circumstance is supposed, by a train of reasonings which we do not clearly understand, to be connected with the supposed line of transit of the early tin trade through the Isle of Wight. Greek coins have previously been found among Roman remains in this country, chiefly in the southern parts of the island and at Exeter, and there is no reason whatever why this should not be the case. Many Greek subjects of the Roman Empire were no doubt in this island, some of them, perhaps, merchants from the islands of the Archipelago and the Eastern Provinces, and the coins found here are such as were in circulation during the Empire. If any coins had been left here at the period of the tin trade, by way of "Icbis," as described by Diodorus Siculus, they would have been, in all probability, not pure Greek, but imitation Greek, that is Gaulish. Among the other objects exhibited was a diminutive, but very elegant, bronze figure of Mercury. The discovery of late years of so many Roman antiquities in the Isle of Wight, shows that that island was largely occupied by the Romans, a fact which we had a right undoubtedly to expect, and probably the principal Roman establishment there lay at Newport and in the immediate neighbourhood. When the Saxons seized upon the island, they also appear to have made this spot their head-quarters, and they gave it, from their chieftain, the name of Wihtgara-burk, from which the modern name of Carisbrook is supposed to be derived. However, the traces of Roman settlement had probably disappeared aboveground during the Saxon period, for the very names of the two towns which appear to occupy Roman sites, Newport and Newtown, where Roman antiquities have also been found, are evidence that when they were founded there were no existing towns there. These names are very significant, and belong to the feudal period. The feudal barons soon began to learn that the regular tribute derived from a corporation of free-traders placed under their protection, was far more advantageous to them than the irregular and violent contributions which they could levy upon traders who passed through their territory, and would of course on that account seek to evade it. They, therefore, sought to draw into their territory commercial settlers, by offering them a place to establish themselves, with the assurance of

freedom of trade and protection. The formation of such towns belong chiefly to the twelfth and thirteenth centuries, and they were called, in the French language of feudalism, *franchevilles* and *neuvevilles*, and in England *Newports*, or *Newtowns*, or, more early, *freetowns*. Newport and Newtown were both foundations of this description—*port*, in Anglo-Saxon, meaning a town which enjoyed certain free institutions.

Among the antiquities from the Isle of Wight were a few of the curious LEADEN SEALS, or stamps, of which we have spoken on a former occasion, and which have been found in larger quantities, and with more unmistakable Roman character, on the Roman site at Burgh-under-Stanemore, or Brough, in Westmoreland. At the last meeting of the Archæological Institute, a Polish antiquary, Count Tyszkievicz, communicated an account of similar leaden seals found at some distance from Warsaw, which were ascribed by the antiquaries of Wilna to a Slavonic race formerly inhabiting that district. There can be little doubt, however, that, as Mr. Albert Way stated before the Institute, they belong to the Roman period, and are, as he then suggested, curious monuments of Roman commerce. The Count with the difficult name believed them to have been of a religious character. The discovery of these leaden stamps in such numbers in the Isle of Wight may fairly be considered as evidence that that island was, in Roman times, a place of some commercial importance; but there is a difficulty in this case arising from the circumstance that, unlike the discoveries at Brough-under-Stanemore (the Roman *Verteræ*), the Roman leaden stamps found in the Isle of Wight have become, accidentally, mixed with somewhat similar objects belonging to the Middle Ages, and even to very recent times. This has led to some confusion, and it is to be hoped that, in future, antiquaries and collectors will be very careful in ascertaining minutely the exact circumstances of their discovery.

The Sunderland papers of the latter days of the month of September speak of the discovery of a remarkable BONE-CAVE at the Ryhope Colliery, by the workmen engaged in quarrying in the limestone rock. The rock was blasted, and in removing the loosened fragments of rock they came upon a large quantity of bones, including several human skulls, numerous skulls of other animals, such as foxes, badgers, etc., and a great quantity of human and other bones. The place where the bones were found was about twenty feet below the surface, and about thirty feet within the bank. The appearance indicated that there had been a cavity in the rock which had at one time been filled with water; but there appears no means of accounting for the presence of the skulls and bones, except that they were washed into the hollow of the rock many centuries ago. Three of the human skulls, one of which was remarkably perfect, having most of the teeth in, with several other human bones, were taken care of by the resident engineer of the colliery, but a large mass of other bones were allowed to be carried away. T. W.

LITERARY NOTICES.

A DICTIONARY OF SCIENCE, LITERATURE, AND ART. Edited by W. T. BRANDE, D.C.L., F.R.S.L. and E., of Her Majesty's Mint, and the REV. GEORGE W. COX, M.A., Lat. Scholar of Trinity College, Oxford, assisted by gentlemen of eminent scientific acquirements. Parts VI. and VII. (Longmans.)—We have on former occasions expressed a general good opinion of this work, and when compelled to make some observations of a contrary description, our objections and remonstrances referred to the department ostensibly under the care of Professor Owen, whose name figures amongst the list of contributors as responsible for articles on "Biological Sciences, comprising Anatomy, Physiology, Zoology, and Palæontology." No one can suppose for a moment that Messrs. Longman would make such use of Professor Owen's name unless they had made arrangements with him by which the purchasers of the new edition of Brande's Dictionary would be entitled to the benefit of his services. It is true that Mr. Carter Blake is associated with him, but it is Professor Owen's name that is expected to win confidence for the papers relating to the subjects which he nominally superintends. In the present number, we can repeat our general commendation of the labours of the various contributors, but the department assigned to Professor Owen is simply disgraceful. We turn, for example, to the article "Infusoria," and we find the subject dealt with in something less than two columns of antiquated rubbish. We are very sorry to feel compelled to speak thus of anything going forth under the learned Professor's sanction, but it would be dishonest to conceal the truth. We are told in this article that Linnæus placed the Infusoria "at the end of his class Vermes, in a genus which he denominated '*chaos*,'" and in chaos Professor Owen is contented to leave them. Cuvier, he informs us, separated the Rotifera from the Infusoria, and "attributed to them a mouth, a stomach, an intestine," etc. "The anterior lobated organ, and its vibratory *denticulations*," are said to form the main external characteristics. Ehrenberg is then said to have brought to light additional organs in these creatures by the application of a microscope superior to that of his predecessors; and this is about all the information that is given. Thus a reader, not possessing more knowledge of the subject than the learned Professor has thought proper to display, would suppose that nothing of consequence had been discovered since Cuvier "attributed" a mouth, etc., to the Rotifers, and Ehrenberg "brought to light additional complexities." We feel bound to tell Professor Owen that this is not dealing fairly with the public, and we should presume it is not acting up to the requisitions of Messrs. Longman. "The second order of Infusoria in Cuvier's system is then introduced to us, and Ehrenberg's polygastric theory, exploded long ago, is once more affirmed; and in a subsequent paragraph the diatoms are actually called *Polygastric Infusoria*, thus repeating a very pardonable error of Ehrenberg at an early stage of inquiry, but what is now a disgraceful blunder for any naturalist to make. We then

turn to "Intestinal Worms," and find an article that might have been written twenty or thirty years ago, before the structure or history of these creatures was understood. This is the more discreditable, since the publication of Dr. Cobbold's *Entozoa* has placed a large body of accurate information within easy reach. The relation of the hydatids to the tape-worms is not explained, and barely alluded to. This article is perfectly useless to any student at the present day. We must carefully guard against condemning the whole work because Professor Owen's part is badly done. Unless he takes reasonable pains to bring the remainder of his papers down to within a few years of the present date, the student may save himself trouble by considering the "biological sciences" omitted from this edition. In other departments, he has a good chance of getting the information which he wants, though now and then a slip is made. Thus the writer of "Irradiation" misquotes the old ballad of "Sir Patrick Spence," and explains what he calls the "*new* moon in the old moon's arms" as an effect of irradiation!

Diarrhœa and Cholera; their Origin, Proximate Cause, and Cure, through the Agency of the Nervous Centres, by means of Ice. By John Chapman, M.D., M.R.C.P., M.R.C.S. (Trübner & Co.) —Dr. Chapman considers summer diarrhœa and cholera to result from over-stimulation of the vaso-motor centres by the heat of hot climates or the summer of temperate climates. This excitation of vaso-motive action induces contraction of the blood-vessels supplying the intestines, and at the same time stimulates the mucous glands. Ice reduces vaso-motor energy, and removes the diseases. This is Dr. Chapman's argument, ingeniously supported by reasoning, and by an appeal to cases. If this is a true explanation of cholera, how does it account for the winter attacks of that malady, which, if we remember right, were very violent some years ago, both in Russia and Scotland? Dr. Chapman stands out favourably from the ordinary run of doctors by having a philosophy, and by having arrived at it through a process of reasoning upon physiological facts. Whether he is right or wrong, numerous experiments must show. He is an independent thinker, and having studied medicine somewhat late in life, he was probably less amenable to the baneful influences in favour of mere orthodoxy and receptivity which medical schools appear to exert on ordinary pupils.

Elements of Physics and Natural Philosophy. Written for General Use in Non-technical Language. By Neil Arnott, M.D. Sixth and Completed Edition. Part II. (Longmans.)—This second part and volume of Dr. Arnott's great popular work treats of heat, light, electricity, magnetism, and astronomy; and in an appendix we find a brief treatise on popular geometry, which might be advantageously extended and published in a separate form. We cannot say that the second volume of the "Elements of Physics" is as good as the first, though it contains much valuable matter admirably put. The portion relating to heat was written before heat was generally considered as a mode of motion; and although modern ideas and discoveries are slightly noticed, they do not occupy the position to which they are fairly entitled. From section 115,

the reader would imagine that a spherical mirror brings parallel rays to one focus. If this were the case, opticians need not trouble themselves to give telescope mirrors a parabolic form. We should have expected Dr. Arnott to give a popular explanation of polarized light, but this subject is passed to "persons who have leisure." We presume this means that the learned doctor had not leisure enough to complete his task.

PHILOCALIA: Elementary Essays on Natural Poetry and Picturesque Beauty. By WILLIAM PURTON, M.A. (Shrimpton, Oxford; Whittaker & Co., London.)—The object of this work seems to be a defence of Aristotle's thesis that poetry is imitation. We do not see that Mr. Purton throws any new light upon the matter.

THE RECORD OF ZOOLOGICAL LITERATURE, 1864. Volume I. Edited by ALBERT C. L. G. GUNTHER, M.A., M.D., Ph.D., F.Z.S., etc., etc. (Van Voorst.)—The object of this book is the praiseworthy one of providing a catalogue *raisonné* of the zoological publications and information of the year. It is not likely that the first volume of such a difficult undertaking should be all that could be desired, but much has been accomplished, and students of natural history will be glad to know that a beginning has been made. Such a work ought to find its place in our chief public libraries.

A DESCRIPTIVE CATALOGUE OF ALL THE GENERA AND SPECIES CONTAINED IN THE ACCOMPANYING CHART OF CRUSTACEA. Showing the Range in Time of the Several Orders, with some Recent Types. Illustrated by upwards of 490 figures, arranged and drawn by J. W. SALTER, A.L.S., F.G.S., and HENRY WOODWARD, F.G.S., F.Z.S., engraved on steel by J. W. LOWRY, F.R.G.S. (Tennant, Strand; Lowry, Robert Street, Hampstead Road.)—We do not remember to have seen any chart of the kind so well arranged, both for reference to the figures, and the explanatory text. The latter occupies a series of pages on the left-hand side of this handsome, double volume, while the chart unfolds to the right. The figures are beautifully engraved, and the work deserves a hearty welcome from geologists and other cultivators of natural history. The various genera and species of crustacea are grouped together, so as to show the geological period in which they are first known to have occurred, and the extent of their persistence in geological time. Figures of modern species are likewise given to a sufficient extent to indicate the changes that have taken place in the crustacean world. Thus, in addition to the value of the chart for the identification of fossils, it conveys a large and valuable amount of really scientific information, compressed into a very convenient and advantageous form. It is very seldom that work of this kind is so judiciously and carefully done.

BRITISH ASSOCIATION CHARTS FOR OBSERVATIONS OF LUMINOUS METEORS. Printed for the British Association Luminous Meteor Committee.—Under this title a series of star-charts, forming a celestial atlas of fourteen plates, was laid before the meeting of the British Association at Birmingham by Mr. Glaisher. The atlas is

intended, according to Mr. Glaisher's report, to enable observers of shooting stars to record their observations in an exact and systematic form. The object of providing star-charts for meteor observations engaged at a very early date the attention of the distinguished astronomer, Bessel, who, in a long and elaborate article on shooting stars contained in the *Astronomische Nachrichten*, vol. xvi., p. 347, thus describes his own experience:—"The course of phenomena so fugitive as shooting stars, too swift to be followed with our instruments, can only be noted and drawn exactly among the stars of an ordinary star-map by hand and by careful watching. Such maps I have always found very inadequate for the purpose, partly because they represent only a small portion of the visible heavens, and partly because they are rendered indistinct for the most part by the images of the constellations drawn upon them. The net or web of these maps is also seldom engraved so close as to allow positions on the maps to be read off to a part of a degree." Regarding these objections as fatal to the use of ordinary star-maps, Bessel devised a new atlas, to be constructed especially for observations of meteors. The project was carried out, and the atlas was completed by G. Schwincke, of Pillau, and published at Leipzic in 1843. It consists of five stereographic charts, 18½ Prussian inches long, and 16¼ wide, representing the visible heavens at Konigsberg, as far as the thirtieth parallel of S. declination, and containing one chart for the North Pole, and four for the region of the equator. Adopting identically the same plan of arrangement, and projecting the sphere upon its circumscribing cube, the late Sir John Lubbock had previously figured the whole visible vault of the heavens upon an atlas of six maps, containing four maps for the equator, and one for either pole. These maps, published in 1836 by the Useful Knowledge Society, owing to their remarkably simple mode of projection, are better fitted for recording shooting stars than those afterwards produced by Bessel. Following the example set before them by Sir John Lubbock in the maps of the Useful Knowledge Society, the Committee of the British Association last year undertook to prepare the present series of star-maps, on the principles of plane perspective projection. As the result of their exertions during the year, Mr. Glaisher presented to the British Association fifty lithographic copies of the complete set of maps. Each map represents the sky as it might be imagined to appear at Greenwich, traced through on a flat transparent ceiling, placed four inches above the eye of the spectator. A single map of the series, twenty-two inches long and eighteen inches wide, includes the whole visible heavens at Greenwich, to within 25° from the horizon on either side, to within 20° degrees at the ends, and to within 16° at the corners of the map. Since the heavens revolve, twelve maps in succession are made to represent, in order, the appearance of the sky at intervals of every two hours throughout the twenty-four, or, according to another commodious form of their adaptation, from month to month throughout the year. The set is numbered and named, from No. 1, January, to No. 12, December, according to the month, in which each map represents faithfully the appearance of the sky at

about ten or eleven o'clock at night. The whole series exhibits a complete cycle of the stars of the constellations of Bode. The net or web on which the maps are constructed, showing, for the entire circumference, and to nearly 15° below the equator, every individual degree of both Right Ascension and Declination was ascertained by Dr. Heis, of Munster, to be correct to a small fraction of a degree. It forms a separate plate in the atlas, so as not to interfere with the distinctness of the other maps. A net of circles of altitude and azimuth is also added, the whole together forming an index of the completest kind for observing and mapping shooting stars. To illustrate by an example the characteristic features of the maps, the branching wings of *Cygnus*, in whatever map of the series they appear, point infallibly to the last star of the tail of *Ursa Major:* and the brightest stars of *Draco* are found, as they are in the sky, in a direct line between these two distant points. The beginning and ends of a meteor's course being noted upon one of the maps, and these two points being joined, the straight line between them, however distant they may be, represents the meteor's course across the sky, from its point of appearance to its disappearance among the stars. Dr. Denison Olmstead, it is well known, explained the existence of the radiant point of meteors, by stating it to be the vanishing point of their straight courses seen in perspective. It happens not unfrequently that the tracks of twenty or thirty meteors, seen on a single night, prolonged backwards upon the maps, are found to intersect each other in a single point. Such a circumstance, where it occurs, cannot be purely accidental; but, on the contrary, it amounts to a positive proof that the point in question is the vanishing point of a series of parallel flights, which together compose a true meteoric shower. The point determined in this manner is the radiant point, whose position determines the axis of the shower, or the general direction of the meteors. Radiant points determined by means of these maps are described in the *Monthly Notices* of the Royal Astronomical Society for Dec. 9, 1864, and March 10, 1865. They have reappeared in the present year, as described at a recent meeting of the Astronomical Society, in such a manner as to show that the dates of meteoric showers, and the positions of their attendant radiant points, are singularly fixed and permanent, and that the meteoric showers themselves, however startling the conclusion may appear to our readers unaccustomed to speculate in astronomy, are a collection of small planetary or cometary bodies coming into direct collision with the earth. The new charts are the work of Mr. Alexander Herschel, to whom this branch of astronomy is, in many other respects, deeply indebted.

Seven Lectures on Scripture and Science. By John Eliot Howard, F.L.S., etc. (Groombridge & Sons.)—We can only state the contents and nature of this work, as a review of its opinions would carry us beyond our boundaries into the regions of critical and polemical theology. The subjects treated by Mr. Howard are—"The Scriptures viewed as the Oracles of God," "The Books of the Old Testament and their Authorship," "The New Testament, its Authority and Authorship," "Colenso and his Diffi-

cultics," "The Six Days of Creation, as given in the Book of Genesis," "The Laws of Nature and Miracles," and "Mysticism as Opposed to the Revelation of God in Scripture." Mr. Howard, though claiming to stand alone as an independent thinker, in the main finds himself in agreement with those who hold what are called orthodox opinions in theology, and who reject all the conclusions of the school of criticism to which Bishop Colenso is attached. The titles of Mr. Howard's chapters, as an indication of his tendencies, will suffice to attract the attention of readers likely to sympathize with his endeavours.

THE ASTRONOMICAL REGISTER. (J. D. Potter, Poultry.)—We are glad to see from the names of subscribers and the character of its correspondence that this monthly periodical is appreciated by many of our best working astronomers. We observe that it frequently renders good service, which only a work devoted to a single subject could undertake.

THE GEOLOGICAL MAGAZINE. Edited by HENRY WOODWARD, F.G.S., F.Z.S., of the British Museum, assisted by PROFESSOR JOHN MORRIS, F.G.S., etc., and ROBERT ETHERIDGE, F.R.S.E., F.G.S., etc. (Longmans.)—This work, in which the defunct *Geologist* has been incorporated, is now in able hands, and supplies a valuable record of facts, many of which could only be collected in a periodical devoted to a single science.

WINTER IN THE SOUTH OF FRANCE; or, Mentone, the Riviera, Corsica, Sicily, and Biarritz, as Winter Climates. By J. HENRY BENNETT, M.D., etc., etc. Third Edition. (Churchill.)—Dr. Bennett has greatly enlarged this work, rendering it exceedingly interesting as a book of European travel, and a valuable guide for invalids seeking a suitable winter residence. It is elegantly got up, with a fine view of Mentone, and other excellent illustrations. Dr. Bennett has tried the climate of Mentone, or Menton, as its French possessors now call it, for six winters, and both in his own person, and in the experience of patients whose cases he has watched, it seems to have been demonstrated that it possesses an invaluable influence in curable forms and stages of consumption. The book abounds in very pleasantly given scientific information, and it is evident that the doctor has a keen eye for objects of natural history, as well as for picturesque scenery, and for those possibilities of comfort without which no invalid should leave his own home.

Dr. Bennett enters into the physical geography of the Mediterranean coast of France and Italy, and shows how the mountains hook round Mentone, shielding it from north and north-easterly winds, and leaving it open to mild breezes and sunny influences. It is from this peculiarity of situation that, although cooler and drier than Madeira in the winter, it is yet much warmer than most other places of similar latitude. Lemons grow there to great perfection, and the olive trees are remarkable for their luxuriance. Dr. Bennett says, "The longevity of the olive-tree in a congenial climate like that of Mentone may indeed be said to be indefinite. There are olive-trees still alive at Monaco, at the Cap Marten, and elsewhere, which are supposed to be coeval with the Roman empire.

It is a slow growing tree, and forms cart-loads of hard roots, which fill and cover the ground where it stands. When, after several hundred years, the trunk decays, the bark still remains alive. As the decay progresses, the tree splits, as it were, into two, three, or more sections. The bark twists and curls round each of these decayed sections, and unites on the other side. Thus, instead of the old tree, we have in its place two, three, or more, apparently separate, although in reality all growing from the same root. When these in turn die, new shoots spring up from the old roots, and thus the life of the tree is indefinitely prolonged." Dr. Bennett gives an interesting plate of grand old trees formed upon this plan. We hope his book will help to convert invalids into observers of natural objects. The want of mental occupation is a powerful hindrance to the comfort, and often to the cure of persons driven from their homes in search of health.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

LIVERPOOL PHILOSOPHICAL SOCIETY.

VENTILATION OF SEWERS.—At the last meeting of this society, Mr. Higginson drew attention to the extract from the *Scientific Review* on the ventilation of sewers, stating that a French chemist had proposed to draw from the sewers a supply of air for the support of the combustion of furnaces in factories, thus destroying the noxious gases by combustion, and supplying fresh air to the sewers. It was stated that the plan was already in use on a small scale. Mr. Higginson stated that he had suggested the same plan to the Social Science Association at Liverpool in 1858.

The advocates of this mode of ventilating sewers seem to be unaware of a fatal objection to its employment, namely, that the gases given out by the decomposing sewage consist chiefly of carburetted and sulphuretted hydrogen, that these are combustible, and capable of forming an explosive mixture with atmospheric air.

The plan was tried in London many years since, during one of the earlier outbreaks of cholera, and a very serious explosion took place in the sewers of the neighbourhood in consequence. As it is impossible to prevent such a result from recurring, or to predict the extent of damage that might ensue, the proposal cannot be regarded as safe.

CHEMICAL SOCIETY.—*Nov.* 2.

DISCOVERY OF CERIUM IN ENGLAND.—Professor A. Church exhibited several new minerals which had been recently discovered in Cornwall. The most interesting of these was a hydrated phosphate

of cerium, and it was important as furnishing the only instance of the occurrence of the rare metal cerium in Great Britain. The other new minerals described were a hydrated phosphate of aluminium and calcium, and a hydrated arseniate of copper and lead.

A communication was also made by Mr. John Hunter on the absorption of vapours by the charcoal obtained from the shell of the cocoa-nut. This possesses a high degree of absorbing power; taking up at the elevated temperature of 90° Cent. no less than 155 times its bulk of the vapours of methylic alcohol.

THE ENTOMOLOGICAL SOCIETY.—*Nov.* 6.

Acclimatization of British Insects in Canada.—Mr. G. J. Bowles communicated a paper on the recent naturalization and rapid spread of the small white cabbage butterfly, *Pieris Rapæ*, in Canada. It is presumed that the insect must have been imported in the condition of eggs or pupæ. For some seasons only a few specimens were seen; but recently the increase of their numbers has been very great. As the *Pieris Rapæ* feeds on a vast number of plants, although selecting in preference those belonging to the cruciferous group, there can be no doubt that it will become a permanent addition to the fauna of the North American continent.

GEOLOGICAL SOCIETY.—*Nov.* 8.

"On the Origin of the Parallel Roads of Glen Roy."—The Rev. R. Boog Watson gave a brief description of these well-known "Roads," in which he analysed the two principal theories that have been started to account for their formation—namely, the Ice-dam theory and the Marine theory. With regard to the first theory, he stated his opinion that although it has some strong points, especially in respect of the coincidence between the levels of the "Cols" at the glen-heads, and those of the "Roads," yet on the other hand it is weak, inasmuch as the cause assigned is extremely local in its action, while the phenomena to be explained are very general and have a wide range—terraces similar to those of Glen Roy occurring in Scandinavia and elsewhere. In the author's opinion, the formation of the "Roads" by an ice-dam is impossible, for the dam would not have been water-tight, and there is no period at which it could have existed during the post-Pliocene changes in Scotland. Objections like these cannot be urged against the Marine theory, as the sea has been on the spot, and is able to perform the work required of it. At the same time the author admitted that the Marine theory is not free from difficulties, the chief being the perfection and horizontality of the "Roads," and their barrenness in Marine organisms.

MICROSCOPICAL SOCIETY.—*Nov.* 8.

THE VEGETABLE PARASITES OF THE HUMAN SKIN.—Mr. Jabez Hogg read a valuable paper on this subject, the object of which was to show that vegetable parasites do not produce the different varieties of skin disease; but that when certain diseases already exist, that the fungi, finding a suitable soil, greatly aggravate and often change the type of disease; that these diseases are always associated with neglect of person, dirt, bad air, want of light, and deficient nourishment; that the spores of fungi are always floating about in the atmosphere, and are thus ever ready to be deposited and take root in a favourable soil; of this Mr. Hogg gave many illustrations, and showed that although yeast, *penicillium*, *aspergillus*, and some other well-known fungi, had been separately classed, that nevertheless they could be made to pass through the same changes, and produce ferments that could not be recognised one from the other; and, therefore, difference of form he believed to be entirely due to the soil or nourishment supplied, and dependent on such circumstances as whether the growth of the fungi takes place in a sickly plant, a saccharine solution, or an animal tissue.

ROYAL GEOGRAPHICAL SOCIETY.—*Nov.* 13.

THE DISCOVERY OF LAKE ALBERT NYANZA.—Mr. S. W. Baker read a paper descriptive of the discovery of this lake. In December, 1862, he started up the Nile from Khartoum with a powerful force, including many camels, horses, and asses. Pursuing his course, he entered upon a dreary waste of water, where he soon lost his only European attendant. The remainder of the party safely reached Gondokoro, where they awaited a trading company, travelling southwards. Gondokoro itself was a wretched place, being occupied only occasionally by traders. After a stay of fifteen days, Captains Speke and Grant arrived, clothed in humble rags, but with the glory of success upon them. Captain Speke told him that he was assured by the natives that a large lake existed to the westward, which he believed would be found to be a second source of the Nile, and that he himself had traced the river up to 2° 20′ N., when it diverged to the west, and he was obliged to leave it. Accordingly he (Mr. Baker) undertook to follow up the stream. The trade along the White Nile really consisted of cattle-stealing, slave-catching, and murder, and the men whom he was obliged to engage at Khartoum were the vilest characters. After Speke and Grant had left him, his men mutinied, threatened to fire upon him, and the Turkish traders whom he intended to accompany set off without him. By means of diplomacy he managed to get back the arms from the recalcitrants, and induced seventeen of the men to go with him to the eastward. He afterwards discovered that they intended to desert him and to join the traders. He followed the trading party who had threatened to attack him, and upon the suggestion of Mrs. Baker, the chief was brought over, and on the 17th of March they safely arrived in the Latooka country,

110 miles east of Gondokoro. That country produced ample supplies of grain and supported large herds. The towns are thickly populated, and the inhabitants are a warlike but friendly race, who go naked, and train their hair into a kind of natural helmet. The bodies of those who are killed in fight are not buried, but those who die naturally are interred in front of the houses in which they had dwelt, and at the expiration of a fortnight are exhumed, the flesh removed, and the bones put in earthen pots, which are placed at the entrance of the towns. From Latooka he proceeded to Kamrasi's country, across an elevated region, the watershed of the Sobat and White Nile rivers. From the ridge he descended into the valley of the Asua, which river Captain Burton regarded as the main stream of the White Nile, but which, when Mr. Baker crossed it in January, did not contain enough water to cover his boots. He crossed Karuma Falls in the same boat which had carried Captain Speke, but he was detained for some days by the disinclination of the King Kamrasi to allow strangers to pass over. From Karuma Falls the Nile flows due west, a rapid stream, bordered with fine trees. King Kamrasi, was very suspicious, and sought to prevent Mr. Baker continuing his journey, by representing that the great lake was six months' journey—a statement which he received as a fatal blow to all his hopes. Learning, however, from a native that the lake could be reached in something like ten days, he induced Kamrasi, by presents, to allow them to depart. In crossing the Karan river on the way to the lake, Mrs. Baker was struck down by a sunstroke, and remained almost insensible for seven days, during which time the rain poured down in torrents.

On the eighteenth day after leaving Kamrasi they came in sight of the looked-for lake, a limitless sheet of blue water sunk low in a vast depression of the country, surrounded by cliffs, 1,500 feet in height. The western shore, sixty miles distant, consisted of ranges of mountains 7,000 feet in height. Mr. Baker named the lake, Albert Nyanza. That lake, together with the Victoria Nyanza, may be regarded as the great reservoirs of the Nile, which issued from the lake precisely as the natives had reported to Speke and Grant, and from its exit the river is navigable as far as the narrows near the junction of the Asua. Mr. Baker's progress up the Upper or Karuma river was stopped, at fifteen miles distant, by a grand waterfall, which had been named Murchison Falls. Upon their return to Kamrasi's country the travellers were detained nearly twelve months, the King being so impressed with the knowledge of his European visitors that he would not let them leave him. Ultimately the travellers managed to get free, and arrived safely at Alexandria.

NOTES AND MEMORANDA.

NOTE ON NITRIDE OF IRON.—It is an ammonium (NFe_4) in which iron takes the place of hydrogen (see Poggendorf's *Annalen*, May, 1865), and is obtained by heating iron in ammoniacal gas; or, better still—as mentioned in the INT. OBS., p. 311—by passing ammonia over pure protochloride of iron; the reactions being $NH_4O + 4\,Fe\,Cl = NFe_4 + 4\,HCl + O$. The hydrochloric acid thus produced unites with some of the ammonia, forming chloride of ammonium, which escapes. But, with regard to the oxygen, it is most probable that, in certain cases, it forms NFe_4O, the analogy with ammonium being thus kept up; that in others it passes off with the chloride of ammonium; and that in others it unites with hydrogen, which is set free during the complicated decompositions that occur when nitride of iron is formed, on account of the nitride being decomposed even by the temperature required for its production, and still more by a higher; nitrides containing varying quantities of nitrogen, and mixtures containing varying quantities of nitride and metallic iron being formed. These mixtures, before the researches of Stahlschmidt, were erroneously considered to be different nitrides.

EXTRAORDINARY FLIGHT OF BIRDS.—A lady, dating from Pont de Briéques, near Boulogne, on the 24th Oct., informs us: "While I write, there comes suddenly a great thick black cloud, accompanied by an extraordinary noise. We are all terrified till we discover the cause. Figure to yourself an innumerable flight of black birds as big as pigeons, and going northwards." Similar flights of birds were seen by M. De la Blanchère in the department of Sarthe, on the 30th Oct. See *Comptes Rendus*.

LUNAR PHOTOGRAPHY.—During the partial eclipse of the moon on the 4th Oct., Mr. De la Rue took a series of seventeen photographs, using Steinheil's 13-inch silvered glass mirror of 10 feet focal length, the action of which he did not find more rapid than that of the speculum metal mirrors of same dimensions and focal length which he had previously employed. This is curious, as the reflective power of the silver film is, according to Sir J. Herschel, to that of the best speculum alloy, as 91 to 67. Mr. De la Rue says—"After contact it was found that while an instantaneous exposure sufficed to give a faint impression of that portion of the lunar disk not obscured by the umbra or penumbra, an exposure of a whole minute failed to bring out the details of the lunar surface covered by the umbra, although its details were plainly perceptible in the telescope. The obscured portion of the moon was moreover perfectly visible without optical aid. Further details will be found in *Monthly Notices* (Supplemental Notice), No. 9.

ζ HERCULES.—In *Monthly Notices* (Supplemental Notice), No. 9, Mr. Fletcher states that at present this star is absolutely single with his 9½ inch refractor, and power of 1000. A few years ago he had no difficulty in measuring the distance of the companion star with a 4-inch telescope; and he shews that as the companion is close to its perihelion, the earliest possible observation of its reappearance will be valuable.

NEW GROWING SLIDE.—Mr. H. L. Smith, of Kenyon College, U.S., has contrived a new growing slide for the microscope. It is composed of two glass plates 3 × 2 inches, and about 1-25th of an inch thick, separated by strips of the same thickness, and cemented by marine glue. One corner of the upper plate is removed, and a very small hole drilled through the upper plate at one corner of the space, to be covered by a piece of thin glass placed over the object whose growth is to be watched. The slide is filled with water by means of a pipette applied to the open corner, and when the covering glass is placed over the little hole, water slowly oozes through, as it is affected by capillary attraction. By this means an object is kept moist. The cell is said to hold water enough for about three days.—*Annals Nat. Hist.*

DIMORPHISM IN MITES.—M. Claparède stated at the last meeting of the Société Helvetique des Sciences Naturelles that dimorphism is found amongst the

Acari, and he instanced the so-called Hypopus, a supposed species of mite found on field mice, bumble bees, flies, ferns, etc., which he has ascertained to be the male of a much larger acarus. The Hypopus has a carapace like a tortoise, and no mouth, or digestive apparatus. The facts described by M. Claparède resemble those elucidated by Mr. Gosse with respect to the males of the rotifers. M. Claparède frequently found the Hypopus and the female form on the same hyacinth bulbs, and he observed that some larvæ of the same acarus had three pairs of feet, and others that were older, four. From these last he witnessed the development of the Hypopus.

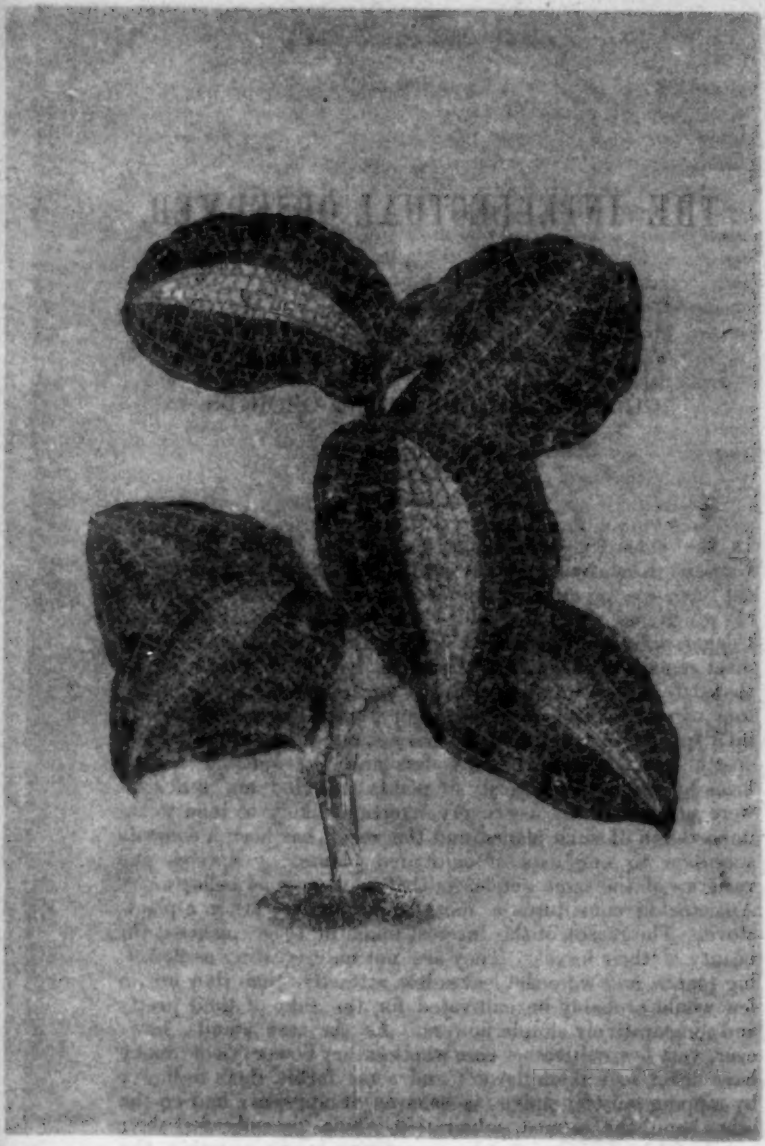
Early Puberty.—M. Ramon de la Sagra communicates to the French Academy a remarkable case of early puberty in a negress. Before she was three years old she exhibited the development customary in girls of her race at thirteen, and her head, which was well formed, and the expression of her countenance would have looked appropriate if placed on the shoulders of a girl of sixteen. At seven years old her figure was fully developed, and her vivacity, intelligence, and manners corresponded with her appearance. M. de la Sagra was not able to continue his observations, and her subsequent history is not mentioned.

Water Spouts at Annonay.—On the 22nd October a tempest occurred in the valley of the Rhone. Thunder was continuous, accompanied by heavy rain and frequent water-spouts (*trombes*). In the streets of Annonay the floods swept away objects of all kinds, including a waggon containing 2000 quintals of iron. Masses of rock brought down by the floods and hurled along the roads excavated the soil, and left many houses hanging over an abyss. In other places masses of stone were piled up to the height of the first floors, and the town was in darkness, as the gas-pipes were unearthed and broken. In the valley of La Deûme workmen were glad to escape from the sudden deluge by getting through the roofs of the factories. A stone pillar, weighing 7,500 kilogrammes, was carried away, together with another object weighing 1500 kilogrammes. The water rose about twenty-six feet, and the damage to paper-mills and other works, together with the ruin of private houses, was very great.

Alleged Law of Meteoric Showers.—M. André Poey states in *Comptes Rendus*, that the periodical return of meteors in August and November appears to be confined to high latitudes of the temperate zone, and probably to glacial regions, while extraordinary showers of meteors in swarms embrace the entire surface of the globe; and he asks whether the northern localization of periodic returns can be explained by supposing the descending node of the orbit of the meteoric swarm to be very much inclined towards the ecliptic.

Volcanic Groups of Etna and Vesuvius.—M. St. Claire Deville observes that sundry communications made to the French Academy by M. Fouqué show that the last great eruption of Etna was coincident with a diminution of eruptive intensity in the Vesuvian group and in the Eolian Isles, which seems to confirm the idea of their being in connection with each other.

Preventing Boiler Incrustations.—*Cosmos* states that a fine clay dug at Fohnsdorf, and diffused through the water in boilers, has been found to put a stop to hard incrustations. The clay particles prevent the consolidation of the deposit, and it accordingly assumes a soft, muddy form, which it is easy to remove.



Anœctochilus xanthophyllus.